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Dear Colleagues,

The International Conference of Young Scientists on Energy and Natural Sciences Issues (CYSENI 2024) has been organized already for the 20th time since 2004, which has become an annual tradition. We are very proud to bring together talented young scientists to participate in the 20th CYSENI conference. We expect that this will contribute to the exchange of ideas, improved knowledge of young researchers, development of their acquired abilities and contribute to the increasing level of exercised research activities. The initiative for such an event came from young and enthusiastic researchers of Lithuanian Energy Institute (LEI). They realized that there are a lot of young, smart and science-oriented young people and they need a place to share their views, generated ideas and present the latest research results.

This year, Lithuanian Energy Institute together with Lithuanian Research Centre for Agriculture and Forestry as well as RTO Lithuania continued a partnership in co-organizing the CYSENI 2024 Conference. This partnership allowed us to expand the topics of the conference and maintain a high number of participants – 150 from 12 countries.

The conference once again has brought together young researchers and scientists to discuss recent trends in energy and natural sciences sectors worldwide. We are pleased that young scientists further found the conference valuable to present their up-to-date research results and share scientific experience. We thank all the contributors who made this conference possible. This includes all people from scientific and organizing committees.

We would like to thank all participants for their contribution to the Conference and submission of their research papers. Moreover, special thanks to Keynote speakers: Akvile Virsile, Sarunas Varnagiris, Gregorio Iglesias, Sebastian Wilhelm, Birute Frercks, Vita Tilvikiene, Ihor Kadenko.

Sincerely,

Conference Organizers

PLENARY SPEAKERS

- **SPEAKER | Akvile Virsile**
  Chief Researcher at Lithuanian Research Centre for Agriculture and Forestry and a Project manager at Energenas, LLC:
  CONTROLLED ENVIRONMENT AGRICULTURE: WHERE TECHNOLOGY MEETS PLANT BIOLOGY

- **SPEAKER | Sarunas Varnagiris**
  Senior Research Associate at the Lithuanian Energy Institute, and Head of the Lithuanian Hydrogen Energy Association:
  HYDROGEN ENERGY AND ITS POSSIBILITIES IN R&D ACTIVITIES

- **SPEAKER | Gregorio Iglesias**
  Head of the Department of Energy Engineering and Professor of Marine Renewable Energy at University College Cork:
  OFFSHORE WIND AND THE ENERGY TRANSITION UNDER CLIMATE CHANGE

- **SPEAKER | Sebastian Wilhelm**
  Research Assistant at Technical University:
  CFD MODELING OF PLASMA-ASSISTED ENTRAINED FLOW GASIFICATION

- **SPEAKER | Birute Frercks**
  Senior Researcher at Lithuanian Research Centre for Agriculture and Forestry, Lecturer at Lithuanian University of Health Sciences:
  THE PROSPECTS OF OMICS IN AGRICULTURE

- **SPEAKER | Vita Tilvikiene**
  Chief Researcher and Deputy Director for Research at the Lithuanian Research Centre for Agriculture and Forestry:
  THE USE OF AGROBIOMASS FOR BIOENERGY - OPPORTUNITIES AND CHALLENGES

- **SPEAKER | Ihor Kadenko**
  Professor and the Head of the Department of Nuclear and High Energy Physics of Physical Faculty, Taras Shevchenko National University of Kyiv:
  DISCOVERY OF A BOUND DINEUTRON AND POSSIBLE IMPLICATION FOR HYDROGEN ENERGY

AKVILE VIRSILE

CONTROLLED ENVIRONMENT AGRICULTURE: WHERE TECHNOLOGY MEETS PLANT BIOLOGY

Controlled Environment Agriculture (CEA) is a broad term that encompasses plant cultivation in high-tech greenhouses, grow rooms, and vertical farming or plant factories. Integrated technologies in these environments allow for the precise control of various plant cultivation parameters, including temperature, lighting intensity, spectra, humidity, CO_2 levels, and details of mineral nutrition. Additionally, evolving electrochemical sensors, spectroscopy, and computer vision applications are taking plant cultivation to a digital level. However, it's important to remember that the plant, as a living organism, remains at the center of these technological advancements. A comprehensive understanding of biological processes and plant-centric research is crucial for the successful development and application of these technologies, especially in an era where digital twins are replacing traditional "green thumbs". Therefore, the goal of this keynote presentation is to provide insights and explore questions such as: where do the boundaries lie between:

- technology and sustainability,
- agricultural aims and natural plant needs,
- horticultural achievements and consumer preferences,
- and the value of vegetables and profitability for the grower?

SARUNAS VARNAGIRIS

HYDROGEN ENERGY AND ITS POSSIBILITIES IN R&D ACTIVITIES

Hydrogen energy is becoming increasingly crucial in addressing today's energy challenges due to its potential for providing a clean, efficient, and versatile energy source. Europe is setting ambitious goals in the hydrogen energy sector as part of its strategy to achieve climate neutrality by 2050. This invokes an increase in investment, subsidies, and other hydrogen-economy supporting mechanisms. However, the industry is still facing many issues that inhibit the development of the hydrogen economy. Some of them can be solved by the contribution of R&D activities from various scientists' groups. During this presentation, the current situation in Europe and Lithuania is reviewed by presenting main issues, tendencies, goals, and forecasts, revealing possible and necessary R&D activities to fill the gap between academia and industry in the hydrogen energy sector in order to develop this future energy sector. Additionally, the main R&D activities of Lithuanian Energy Institute, Center for Hydrogen Energy Technologies are presented, reflecting the hydrogen energy topic.

GREGORIO IGLESIAS

OFFSHORE WIND AND THE ENERGY TRANSITION UNDER CLIMATE CHANGE

Offshore wind energy is poised to play a fundamental role in the energy transition. Unlike onshore wind, it is not hindered by the scarcity and cost of land. Another advantage is that winds are typically steadier and stronger offshore. In this presentation we shall be exploring two important themes for the future of offshore wind in Northern Europe, with a focus on the Baltic Sea. First, for the offshore wind sector to develop, it has to be viable from an economic point of view. As with any energy project, the fundamental metric to assess the economic viability of offshore wind is the Levelised Cost of Energy. We shall discover that the LCOE of offshore wind in Northern Europe (including the Baltic Sea) is competitive. The second theme is another important issue for the future evolution of the sector - the effect that climate change may have on offshore wind resources. We shall see that the anticipated declines of offshore wind resources under climate change are less significant in the Baltic Sea than elsewhere.

SEBASTIAN WILHELM

CFD MODELING OF PLASMA-ASSISTED ENTRAINED FLOW GASIFICATION

A closed-loop carbon economy requires efficient conversion processes to produce high-caloric syngas from biomass and residues. This syngas can then be further processed to valuable base chemicals. Plasma-assisted entrained flow gasification with steam as a working medium is a promising technology for producing hydrogen-rich syngas and achieving high carbon recycling rates. This keynote presents the whole research approach of plasma-assisted entrained flow gasification at the Chair of Energy Systems at TUM, containing the general concept development, experimental investigations, and CFD modeling.

The general concept development offers fundamental considerations for beneficial process conditions. These investigations promote steam-based plasma gasification as an efficient process to convert biomasses into base chemicals like methanol, as the steam enhances the hydrogen and oxygen content of the syngas required for methanol synthesis.

Two experimental setups for a mechanistic process understanding are shown, and the main research questions for these setups are discussed. The 1.5kW horizontal plasma reactor aims for a detailed understanding of the influence of plasma in the initial contact zone with fuel particles. With the 50kW plasma reactor currently under construction, the process will be demonstrated in a pilot-scale reactor size. The research focuses on integrating plasma and particle feeding in a gasification reactor, optimizing conversion behavior, and maintaining stable operating conditions.

The CFD modeling approach for plasma gasification is presented in the central part. The approach used in the simulations treats plasma as a hot gas stream, neglecting most dissociation effects and ionization of the plasma. Simulation results of a pilot-scale reactor located at the Chair of Energy Systems, under construction for plasma gasification for experimental investigations, and a theoretical 10MW reactor model to investigate the process on an industrial scale power size are presented. Both reactor models are simulated in plasma and conventional gasification operations, and results are compared in detail. The switch to plasma operation shows similar trends in both cases, namely an enhanced hydrogen content in the syngas beneficial for methanol synthesis but a reduced char burnout. This can be mainly explained by reduced residence times of the particles in the reactor, especially in the zones of the highest temperatures due to higher inlet velocities and a slightly reduced partial pressure of the gasifying agents for char burnout in most zones of the reactor.

Furthermore, the applicability of the modeling approach is discussed. The areas in which the effect of plasma is noticeable in the reactor are extremely small, meaning that in most of the

areas of the reactor, known conditions from conventional gasification prevail. This finding indicates a sufficiently accurate applicability of the approach.

A particular focus of the presentation lies in the interconnection between the three research disciplines, and the synergy effects of these disciplines working together are highlighted.

BIRUTE FRERCKS

THE PROSPECTS OF OMICS IN AGRICULTURE

With the recent acceleration of climate change the plants need to adapt more rapidly to their impact. Therefore, efficient strategies to strengthen plant immunity in response, including against pathogens must be developed. In recent years the advances in omics approaches such as genomics, transcriptomics, proteomics, and metabolomics were successfully integrated in plant breeding. A special case of omics is microbiomics. The plant microbiome is a composition of microorganisms occurring within and around a plant and can be either beneficial or damaging plants. In this review the examples how each omics is applied to get more understanding and to improve the plant breeding will be presented.

VITA TILVIKIENE

THE USE OF AGROBIOMASS FOR BIOENERGY - OPPORTUNITIES AND CHALLENGES

Energy security is one of the most important tasks for each country, especially in nowadays. Agrobioenergy diversifies a country's energy sources, reducing dependency on fossil fuels and mitigating the risks associated with volatile global energy markets. It provides a domestically-sourced, renewable alternative, enhancing energy security. Unlike fossil fuels, agrobioenergy typically generates fewer greenhouse gas emissions, contributing to efforts to mitigate climate change. Additionally, it often involves sustainable agricultural practices that can improve soil health, water quality, and biodiversity conservation.

Agrobioenergy projects can stimulate rural economies by creating jobs in agriculture, bioenergy production, and related industries. This can help revitalize rural communities, reduce unemployment, and alleviate poverty. Growing crops for bioenergy can offer farmers additional revenue streams, supplementing income from traditional agricultural activities. This can provide stability in the face of fluctuating commodity prices and market conditions. By producing energy from locally-grown biomass, countries can reduce their reliance on imported fuels, enhancing energy independence and reducing exposure to geopolitical risks.

The development of agrobioenergy technologies drives innovation in agriculture, biotechnology, and energy production. This fosters technological advancements that can have broader applications beyond the bioenergy sector. Nevertheless, agrobioenergy can also utilize agricultural residues, organic waste, and byproducts that would otherwise be disposed of or left to decompose, turning them into valuable energy resources. This promotes resource efficiency and waste reduction. Many countries have set renewable energy targets as part of their commitments to combat climate change and transition to a low-carbon economy. Agrobioenergy contributes to meeting these targets by providing a renewable source of energy.

Overall, agrobioenergy represents a multifaceted solution that addresses energy, environmental, economic, and social challenges, making it an important component of a sustainable energy portfolio for many countries.

Opportunities:	Challenges
Renewable Energy Source	Competition with Food Production
Abundant Resource	Land Use Change
Diversification of Energy Sources	Resource Intensity
Rural Development	Logistical Challenges
Waste Utilization	Technological Barriers
Carbon Sequestration	Policy and Regulatory Uncertainty
Technological Innovation	Economic Viability

IHOR KADENKO

DISCOVERY OF A BOUND DINEUTRON AND POSSIBLE IMPLICATION FOR HYDROGEN ENERGY

In this work, we summarize available results to indirectly observe a bound dineutron in the (n, ^{2}n) nuclear reactions on ^{159}Tb and ^{197}Au and its some properties to characterize the dineutron as a unique nucleus with the magic number two. Upon its comprehensive studying and subsequent discovery, this could open the row with N=2 magic number in Interactive chart of nuclides. We present estimates for the binding energy of a bound dineutron in a singlet state, its radius and possible half-lives. As a neutron excess nucleus, the dineutron must possess a beta-minus decay. Therefore, the decay products of a bound dineutrons are the deuteron, electron and the electron antineutrino. To finalize discovery of a bound dineutron, its decay product must be observed. The only chance to observe the dineutron is to measure an electron spectrum. From this decay spectrum we can derive the endpoint energy, average energy and even an experimental estimate of the half-life. To experimentally observe the dineutron with certain statistical significancy the experiment must be carefully planned. Therefore, the Geant4 model has been developed to simulate the decay of bound dineutrons and detect electrons as one of decay products of the dineutron. The results obtained could provide a positive assurance of the existence of a bound dineutron within 190-560 keV energy region of the instrumental beta spectrum.

In one of our experiments, low energy nuclear fusion reactions were observed and considered at possible occurrence owing to dineutron formation in the outgoing channel of a neutron induced nuclear reaction on ^{159}Tb. Due to dineutron presence and disintegration, the dineutron or it`s decay products may interact with ^{158}Tb nuclei to transform them into ^{160}Tb or directly to ^{160}Dy, in fusion processes. With a simple theoretical model, we demonstrated the possibility of such phenomenon.

Besides that, some publications, dealing with hydrogen energy, provide inside into other mechanisms of nuclear reaction between the dineutron and the deuteron leading to fusion under room temperature conditions with positive energy balance. This also discussed in our work and corresponding estimates of release energy are provided.

CONFERENCE PAPERS

1. ENERGY SCIENCES

1.1. Smart Energy Systems

OPTIMIZATION OF RENEWABLE ENERGY SYSTEMS: A REVIEW

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ABSTRACT

This paper presents an in-depth review of the recent studies on optimizing hybrid renewable energy systems, which cover medium energy demand. The systems incorporate renewable energy sources such as solar, wind, hydro, biogas and thermal, complemented by various storage solutions. The review investigates the mathematical methods and objective functions used in the optimization process, providing a thorough analysis of the advantages and drawbacks of each practice. Secondly, the primary research trends are systematically mapped out in various aspects. This paper also advocates for the broader use of green hydrogen in energy communities, given its potential as a clean and efficient energy carrier. Widely diversified energy portfolio enhances the resilience and sustainability of hybrid renewable energy system. In conclusion, observing the trajectory of the global energy landscape, this paper provides significant insights into the present condition of renewable energy system optimization and suggests potential avenues for future research.

Keywords: optimization algorithms; hybrid renewable energy systems; energy community strategy

A REVIEW OF THE ROLE OF AI INTEGRATION WITH BUILDING ENERGY MANAGEMENT SYSTEMS IN ENHANCING BUILDING EFFICIENCY

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ABSTRACT

Amid the global emphasis on energy efficiency, efforts are being made in the Building Energy Management System (BEMS) field to mitigate climate change and reduce greenhouse gas emissions. A significant gap, referred to as the performance gap, exists between predicted and actual energy performance in buildings, posing challenges to energy efficiency. This study provides a comprehensive review of the factors contributing to the performance gap, such as the complexity of building systems, poor data quality and lack of data availability, poor maintenance, and the variability of occupant behaviour. Living in an era signified by extensive data and the fast-growing capabilities of Artificial intelligence (AI) presents opportunities to integrate AI into BEMS to enhance energy efficiency. The application of AI enables dynamic and adaptive control strategies as well as real-time adjustments based on building and environmental conditions. Through AI, systems can continuously learn from historical data and optimize energy consumption predictions, reducing the performance gap. This study highlights the pivotal role of various AI model applications in BEMS and their potential benefits in predicting a building's energy consumption and system performance for more sustainable buildings.

Keywords: Artificial Intelligence, Building Energy Management Systems, Energy Efficiency, Performance Gap.

1.2. Renewable Energy Sources

SOLAR PRODUCTION WITH DEMAND THROUGH TILT OPTIMIZATION - CASE STUDY FROM JORDAN

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ABSTRACT

In Jordan, abundant sunshine presents a prime opportunity for solar energy adoption. However, the current mismatch between solar production peaks and peak electricity demand poses a challenge. This mismatch often leads to surplus energy during the day, requiring reliance on costly and inefficient battery storage systems. This study tackles this challenge by exploring how strategically adjusting the tilt angle of solar panels can shift their production hours closer to peak consumption times. We move beyond the traditional south-facing orientation and analyse the impact of various tilt angles through real-world experimentation.

Our primary findings indicate that optimizing the tilt angle can lead to a measurable shift in production times. This means we can effectively "tune" solar panels to generate more electricity during peak demand periods, significantly reducing the need for energy storage. This approach enhances the efficiency of solar energy utilization and promotes a more sustainable energy system for Jordan by minimizing resource utilization for storage infrastructure.

The study offers a viable and practical solution for maximizing the value of solar energy in Jordan and similar regions with distinct production and consumption patterns. We can pave the way for a more resilient and environmentally responsible energy future by harnessing sunlight for peak times through tilt optimization.

Keywords: Solar energy, Time-shifting, Peak demand, Tilt optimization, Jordan, Storage.

PREREQUISITES FOR INTEGRATION OF GREEN HYDROGEN AND BIOMETHANE PRODUCTION PROCESSES IN A REAL WASTEWATER TREATMENT PLANT

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ABSTRACT

Achieving the goals of climate neutrality is inseparable from the sustainable development of modern cities. Cities take up only 4% of the EU land area, but they are home to 75% of EU citizens. This number is expected to rise to 85% by 2050. Worldwide, cities consume more than 65% of energy and account for more than 70% of CO_2 emissions. The EU Cities Mission aims to deliver at least 100 climate-neutral and smart cities by 2030 and ensure that these cities act as experimentation and innovation hubs to enable all European cities to follow suit by 2050.

Municipal wastewater treatment plants are among the starting points when moving cities to Net-zero Greenhouse Gas (GHG) emissions and climate neutrality. A wastewater treatment plant (WWTP) can be analysed as an energy system with certain inputs and outputs. Currently, such systems have a significantly negative energy balance, and, in addition, fossil fuel energy sources are used. This situation has facilitated research efforts to make such energy systems neutral or even positive by integrating biomethane and hydrogen technologies, which is the main topic of the present work. GHG emissions in WWTP arise from on-site energy use (electricity used for pumping and aeration, natural gas for heating, etc.) and energy use for transportation (transporting waste to and from the facilities as well as off-road vehicles operating within the facilities).

The prerequisites for the integration of green hydrogen and biomethane production processes are identified and their analysis is performed in present study. First of all, the possibility to utilize all the products formed during the hydrogen production process in the WWTP should be considered in the analysis of prerequisites. By-products (oxygen and heat) can be used in wastewater treatment and biogas production processes. Hydrogen can be used for CO_2 methanation, thereby increasing biomethane production by about 1.6 times and minimizing CO_2 emissions. A very important condition is the availability of green electricity for the production of green hydrogen in terms of quantity and time, including the possibilities of green electricity production in the territory of the WWTP itself. Special attention should be paid to the volatility of the supply of green electricity. Therefore, the possibilities of storing various types of energy - electricity, heat, hydrogen, biomethane, oxygen - must be evaluated. Another condition is the use of renewable energy carriers produced in WWTP, primarily by replacing diesel with biomethane and hydrogen in WWTP transport. The availability of external infrastructure plays an important role - firstly gas and heat networks for the sale of surplus energy products. Finally, an analysis must be carried out to see if the amount of wastewater or other waste is sufficient for the efficient functioning of such an energy system.

As a result, this study gives a list of the technical prerequisites for the integration of green hydrogen and biomethane production processes in a wastewater treatment plant. The analysis of identified prerequisites is performed for a real WWTP of a Lithuanian city selected for the EU Mission “Climate-Neutral and Smart Cities”. The analysis demonstrated that the main prerequisite for the integration of green hydrogen and biomethane production processes is the possibility of utilizing all the products formed during the hydrogen production process. However, for achieving the viability of the above-mentioned combined energy systems all identified prerequisites must be evaluated comprehensively by modelling this system, which is foreseen in the future.

Keywords: renewable energy, biomethane, green hydrogen, wastewater treatment, climate-neutral and smart city, integration

ENHANCING BIOGAS EFFICIENCY: ENVIRONMENTAL IMPACT OF VARIOUS FEEDSTOCK PRETREATMENT TECHNOLOGIES

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ABSTRACT

The impact of biomass pretreatment on environmental aspects and the enhancement of biogas or biomethane yield is a significant area of research. The pretreatment methods, designed to break down the complex structures of various biomass types, have direct implications on both the environmental footprint of the process and the efficiency of biogas production.

Pretreatment techniques, especially for manures and lignocellulosic biomass, play a pivotal role in reducing the emissions of biogas production. By breaking down the complex structure of lignin and enhancing the accessibility of cellulose and hemicellulose, these methods reduce the energy input required for biomass breakdown during anaerobic digestion. These pretreatment methods may significantly increase the yield of biogas and biomethane. By improving the breakdown of organic material in the biomass, these methods enhance the efficiency of the anaerobic digestion process. For instance, certain pretreatment methods can increase the surface area of the biomass, making it more accessible to microbial action, which directly translates to higher biogas.

Methodology: The study used Life Cycle Assessment (LCA) technique to evaluate the environmental impacts associated with the utilization of various feedstocks in biogas production, focusing specifically on the effects of biological using rumen fluid, chemical – using carbon dioxide injection, and biological products additives (BPa) pretreatments. The environmental impact analysis was executed using the SimaPro 9.1 process modelling software. Information related to the necessary technological equipment was extracted from the Ecoinvent v3 database. The impacts of these processes were quantified using the CML-I calculation method. The study's unique aspect involved comparing the global warming emissions resulting from different pretreatment processes, thereby determining their respective Global Warming Potential (GWP) impacts.

Results: The manure energy value obtained from manures after CO_2 pretreatment increased by 21.6–31.2%. After microbial pretreatment with rumen fluid the biogas yield from the same feedstock indicated a notable pretreatment efficiency of 12% on alfalfa leaves biomass. The addition of biological product during pretreatment resulted in a substantial 20.8% increase in biogas yield compared to untreated straw. Biogas production processes are more efficient and environmentally sustainable when biomass is pretreated before being combusted. The utilization of renewable energy sources can be significantly improved through further research and development in this area.

Keywords: Biogas, biomethane, pretreatment, LCA, environmental, impact

SELECTION AND DEPOSITION OF OPTIMALLY FORMULATED SOLUTIONS FOR COBALT SULFIDE LAYERS ON FTO GLASS SURFACE

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ABSTRACT

With the rapid growth of humanity and the development of technology, the need for energy is constantly increasing. Therefore, alternative ways of extracting energy are attracting increasing interest. The search for new semiconductor materials suitable for efficient solar energy conversion and lowering the cost of solar energy is currently attracting a lot of attention due to their physical, chemical, electronic and optical properties. Due to their stoichiometric diversity, cobalt sulfides (Co_xS_y) exhibit a large bandgap spectrum (0,078-0,9 eV, 1,69 eV, 1,81 eV and 2,42 eV), which enables them to capture a significant portion of the energy across the solar spectrum, making them highly appealing for the development of solar cells. Moreover, they are non-toxic, cost-effective, resilient to environmental and temperature variations, and exhibit a prolonged lifespan. This knowledge has led to new research into the formation of cobalt sulfide layers on the glass surfaces with the aim of improving their electrical conductivity and their potential application in the manufacture of solar cells.

The aim of the work is to synthesize the semiconductor cobalt sulfide and obtain its thin layers on the FTO glass surface. As a substrate for the deposition of cobalt sulfide layers, FTO (fluorine doped tin oxide coated) glasses prepared by Ossila.com and FTO glass covered with a TiO_2 layer were used. Prior to the deposition of the cobalt sulfide layers, the FTO glasses were additionally treated. First, with a multimeter (Multi Display DMM), the conductive side of the glass (the surface on which cobalt sulfide layers were later deposited) was determined. In order to make this surface as clean as possible, the glasses were washed with soap and distilled water, placed in beakers with acetone and kept in an ultrasound bath (SonoSwiss Ultrasound Bath, Switzerland) for 10 minutes at 40 ºC in the "sweep" mode. After that, they were dried in an oven at a temperature of 130 ºC and kept in a desiccator over silica gel granules. 0.1 M cobalt sulfate heptahydrate salt ($CoSO_4 \cdot 7H_2O$) was used as a Co(II) precursor. As a source of sulfur ions, two compounds were chosen - 1.5 M thiourea ($(NH_2)_2CS$) and 0.1 M sodium sulfide nonahydrate salt ($Na_2S \cdot 9H_2O$). Since the Co_xS_y layers were also deposited in an alkaline medium, the Co^{2+} cation was stabilized by adding the reducing agent hydroxylammonium sulfate ($(NH_3OH)_2SO_4$) or by converting it to the complex form $[Co(NH_3)_4]^{2+}$ with 25% ammonia solution or ammonia buffer. Finally, using these chemicals, five solutions of different composition were prepared to obtain cobalt sulfide sediments. For this, solutions containing cobalt and sulfur precursors were mixed in test tubes, which were kept in a water bath at a temperature of 100 ºC for 30 minutes and the processes occurring during the reaction were observed.

After examining the sediments obtained visually and by X-ray diffraction analysis, they were deposited on the surface of FTO and FTO/ TiO_2 glasses using dip coating, spin coating and layer by layer deposition methods. The resulting layers were examined using an electron microscope.

Keywords: cobalt sulfide, semiconductor, FTO, solar energy

ASSESSING THE EFFECT OF FOLIAR APPLIED CHITOSAN ON WHEAT GROWN IN COPPER AND ZINC CONTAMINATED SIMULATED WASTEWATER

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ABSTRACT

Wastewater (WW) is one of the common causes to deposit Cu and Zn in soil especially when farmers are compelled to use WW as an alternate to irrigate their crops under shortage of water. Wheat is one of important cereals grown around the globe. Various attempts have been done to mitigate the negative effects of metal toxicity in crop plants. However, very few efforts have been done to use chitosan to ameliorate metal toxicity in crop plants. Thereby, this pot experiment evaluates the influence of chitosan foliar application in wheat grown in contaminated WW. Irrigation was applied till the harvest as following treatments of WW and chitosan (i) Control: irrigation with simulated wastewater with 0, 10, 100 mg L^{-1} of chitosan foliar spray, (ii) Cu: irrigation with Cu contaminated WW @20 mg L^{-1}, with 0, 10, 100 mg L^{-1} of chitosan foliar spray, (iii) Zn: irrigation with Zn contaminated @100 mg L^{-1}, with 0, 10, 100 mg L^{-1} of chitosan foliar spray and (iv) CuZn: irrigation with both Cu and Zn contaminated WW @20 and 100 mg L^{-1}, with 0, 10, 100 mg L^{-1} of chitosan foliar spray, respectively. In results, Cu and Zn contamination negatively affected the shoot dry mass (SDM) and chlorophyll contents of wheat but chitosan foliar application improved these parameters significantly. Maximum reduction in SDM and chlorophyll contents occurred when irrigated with Cu contaminated WW by 17% and 19%, respectively, in comparison to control. Chitosan foliar application remained effective only at highest level of 100 mg L-1. On average, chitosan application, improved SDM and chlorophylls by 18-20% and 18-25%, respectively. However, maximum increase in SDM and chlorophylls was observed with highest level of chitosan foliar spray 100 mg L-1 by 20% and 25% under CuZn contamination.

Keywords: chitosan, copper, zinc, shoot dry mass

INVESTIGATION OF HYBRID RENEWABLE ENERGY SYSTEM APPLICATION IN INDUSTRIAL SECTOR

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ABSTRACT

Hybrid energy systems (HESs), or hybrid power, bring together different generation, storage, and consumption technologies in a single system, improving the overall benefits compared to a system that depends on a single source. Moreover, the industry is driving the use of hybrid power systems due to cost savings, decreased pollution, and connectivity to other power sources like solar panels. So far, hybrid power systems have been combining renewable energy sources (wind and sun) with diesel generators to provide an adequate and reliable power supply. Due to the growing demand for energy sustainability and renewable energy sources, commercial and industrial sectors are refocusing their attention on wind, solar, and hydrogen sources.

In this article, a HES for an industrial company is investigated. An analysis of optimally sized HES has been performed, and the solar and wind generation of the hybrid system has been compared with the load and the amount of energy used and wasted. Solar and wind power generation profiles were created from real-life applications, and different installed capacity cases were analysed. A mathematical model was created to determine the optimal HES component configuration for a given power demand profile. Matlab and Excel tools were employed for the analysis.

Results have shown that HES efficiency heavily depends on the capacity factor of a solar and wind power plant, which in turn is driven by the meteorological conditions of the site. The HES economic profitability increases with an increasing share of direct power consumption. Also, the prospects of hydrogen generation facility integration into the hybrid power supply system are analysed and discussed. Finally, guidance for businesses on the feasibility of using a hybrid system will be provided, together with an overview of hybrid systems used worldwide in industrial plants.

Keywords: hybrid energy systems, renewable energy, optimisation, solar and wind generation, industry

MULTI OBJECTIVE OPTIMIZATION OF A PARABOLIC TROUGH SOLAR COLLECTOR POWER PLANT

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ABSTRACT

Within the scope of this study, the optimization of a solar energy-powered energy production system will be carried out with a multi-objective optimization method. In this context, the heat transfer fluid heated by parabolic trough collectors is transferred to a heat exchanger. The heat from the heat exchanger is transferred to an "Organic Rankine Cycle", and work is produced by the turbine, and this work is converted into electricity with a generator. The remaining heat is used in the district heating system. There are many variables here, such as the size of the solar energy system, operating conditions, solar irradiation, operating pressures of the Organic Rankine Cycle, and turbine inlet and outlet temperatures. First, energy analyses will be performed for the base case scenario. Second, an exergy and economic analysis of the system will be done. Finally, work output and unit cost will be calculated. Under the aim of this study, in this model at least two objective functions simultaneously will be optimized based on these variables. A weighted graphical optimization model will be used in this model.

Keywords: Solar Energy, Optimization, Thermo-economic Analysis

THE INFLUENCE OF INTRODUCING WHITE MUSTARD AS A COVER CROP ON MYCORRHIZAL COLONIZATION INTENSITY OF CASH CROPS UNDER DIFFERENT TILLAGE PRACTICES

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ABSTRACT

Mycorrhizal fungi are a major functional group in soil, capable of supporting ecosystem services by generating favourable symbiotic relationships with many plant species. However, certain agricultural practices have negative influences on arbuscular mycorrhizal fungi (AMF) abundance and functions. It was reported that conventional tillage practices reduce AMF hyphal survival and proliferation thus reducing the benefits of the symbiosis to associated plants and soil. Moreover, some plant species used as a cover crop (CC), particularly from *Brassicaceae*, are non-host for AMF and might inhibit the formation of symbiotic relationships in the following crop. Since they produce a wide range of secondary metabolites and exudates that have antimicrobial effects thereby suppressing the AMF. Thus, it is currently unclear the effect of introducing non-mycorrhizal plants as a CC on the AMF colonization intensity to the following cash crop in the cereal-based cropping system. Therefore, the present study aims to assess the effect of CC white mustard on the intensity of wheat root colonization by AMF in a cereal-based cropping system. The study was carried out in 2022-2023 as a part of long-term field experiment. White mustard seeds (~ 25 kg ha-1 seed rate) were spread with a fertilizer spreader, ~10 m on one side of the test 2-3 weeks before harveg. Sampling of wheat roots was performed after 50-55 days from seeding (flowering stage). The root fragments were placed on slides, fixed with Canadan balsam, and then observed under a light microscope. The preliminary study results indicate that tillage was the main factor regulating the colonization intensity of AMF. Conventional tillage practices disrupt the physical structure of the soil, breaking apart the hyphal networks of mycorrhizal fungi. This disruption caused the reduction under conventional tillage in the efficiency of AMF colonization of wheat roots that couldn't readily connect to the existing mycorrhizal network. Wheat root AMF colonization intensity (M%) was comparatively greater in blocks without introducing white mustard. The results also suggest that conservation tillage can be a strategic mitigation approach to counter potential reductions in AMF colonization of cash crop roots post-*Brassicaceae* cultivation.

Keywords: mycorrhizal fungi, tillage, white mustard

RECOVERY OF PRECIOUS METALS FROM PCB BOARDS IN WASTE CELLPHONES

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ABSTRACT

The proliferation of electronic devices, notably cell phones, has resulted in a global surge in electronic waste (e-waste). Printed circuit boards (PCBs) found within these devices are laden with valuable metals, including precious metals like gold, silver, and palladium. Recycling these metals from discarded PCBs not only aids in mitigating environmental degradation but also conserves natural resources and diminishes the need for virgin materials. This research aims to evaluate the amount of precious metals (Au, Ag, Pd) that could be recovered from the cell phone's PCB waste by pyrometallurgical and hydrometallurgical processes. The methodology is based on the material flow analysis for the phone models from 2001 to 2014, using 20.02 million cell phones' PCBs in the Egyptian market. Our study found that the total amount of precious metals present in the waste of cell phones' PCBs were 545.5 Kg, 842 Kg, and 213 Kg for Au, Ag, and Pd, respectively. Precious metals represent about 1.6% of total cell phones' PCB waste. Silver was found to be the most abundant valuable metal in the cell phones' PCB waste. Continued research and collaboration are essential to driving the development and adoption of advanced recycling technologies for effective e-waste management.

Keywords: Cellphone, PCB board, Waste, Precious metals, Recycling

CASE STUDY ON SOLAR POWER PLANT PARKS AND HEAT PUMPS - INFLUENCE OF VARIABLE SEASONAL COEFFICIENT OF PERFORMANCE (SCOP)

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ABSTRACT

This research underscores the significance of solar energy in optimising the building sector and developing climate-neutral structures. The case of Lithuania, with its deployment of remote solar power plants, illustrates the versatility of solar energy application irrespective of the consumer's location, solar irradiance levels, or technical installation capabilities of solar systems, thanks to the networked distribution of solar power from distant plants. This study delves into the influence of varying Seasonal Coefficient of Performance (SCOP) values of both air and ground source heat pumps when integrated with solar power generation, aiming to identify configurations that maximise energy efficiency. Focusing on an apartment unit equipped with a heat pump and powered by electricity from a remote solar power plant, this research evaluates different scenarios to reflect seasonal variations and the effectiveness of heat transfer in both air and ground source systems. In this study, SCOP values were utilized from commercially available air and ground source heat pumps. The findings indicate that for the A+ energy class residential building examined, thermal energy consumption for heating - when comparing air source to ground source heat pumps (with averages calculated across different SCOP values) - shows a difference of 5.14%. Notably, the use of an air-to-air heat pump is associated with a lower average thermal energy consumption for heating. Opting for ground source heat pumps that boast higher SCOP values can lead to a significant reduction in the building's thermal energy consumption - 35.68% less compared to using a ground-source heat pump with a lower SCOP value. In the case of air source heat pumps, this reduction can be even more substantial, reaching up to 64.14%. Furthermore, the consumption of primary energy (from solar energy) varies with the SCOP of the heat pump used. Specifically, employing an air-to-air heat pump with high SCOP value can decrease primary energy use by as much as 56.38%, whereas utilizing a ground source heat pump can achieve a reduction of 35.69% comparing to a heat pump with lower SCOP value. Such an analysis offers a comprehensive understanding of potential energy savings, environmental advantages, and the practicalities of implementing integrated renewable energy solutions in residential areas. The objective is to provide meaningful insights for the design and operation of climate-neutral residences, especially pertinent to climates akin to Lithuania, where unique challenges and opportunities for renewable energy use exig. This study proposes a scalable model to enhance the sustainability of residential heating and cooling systems through the synergistic employment of solar power and heat pumps, aligning with the investigation's focus on the influence of variable SCOP on solar power plant parks and heat pumps.

Keywords: Solar Energy, Climate-Neutral Buildings, Seasonal Coefficient of Performance (SCOP), Air Source Heat Pumps, Ground Source Heat Pumps, Renewable Energy Solutions, Energy Efficiency, Residential Heating and Cooling Systems.

1.3. Hydrogen energy and fuel cell technologies

COBALT DOPING CONCENTRATION EFFECT ON NICKEL HYDROXIDE USABILITY AS AN AUXILIARY ELECTRODE FOR WATER SPLITTING

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ABSTRACT

Decoupled electrolysis is a promising method for generating green hydrogen that can be used for energy storage. However, effective decoupling of oxygen evolution reaction (OER) and hydrogen evolution reaction (HER) requires effective mediators that can be repeatedly oxidized and reduced. A promising material is nickel hydroxide, which is well known for its excellent electrochemical activity. However, it suffers from one major drawback - OER reduction potential in basic media and Ni(OH)2/NiOOH oxidation potential are very close. This could be remediated by cobalt doping.

Cobalt doped nickel hydroxide was synthesized via coprecipitation in alkaline media with Ni/Co molar ratio of 1:0, 2:1, 1:1, 1:2, 0:1. Samples were characterized using X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD) and scanning electron microscopy (SEM). The nickel-cobalt powder was mixed with carbon black (Vulcan X72) and polyvinylidene fluoride (PVDF, Mw=530000) in a mass ratio of 8:1:1. This mixture was dispersed in N,N-dimethylformamide to prepare electrically conductive inks. The inks were used to impregnate carbon felt samples that were used as working electrodes for material electrochemical characterization. The electrode materials were tested using cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS) and chronopotentiometry (CP).

The XRD pattern of all the analysed samples showed distinct peaks at approximately 19°, 33°, 38°, 52° and 59° 2Θ degrees. The peak position corresponds to Ni(OH)2 (Theophrastite) and Co(OH)2. However, they are almost coincident. SEM micrographs showed that the synthesized Co-doped nickel hydroxide samples had a broad particle-size distribution, but increasing cobalt concentrations were distinguished by a larger fraction of fine particles. Overall, the hydroxide particles were irregularly shaped and were characterized by sharp edges.

The Co-doped nickel hydroxide cyclic voltammogram showed a single distinct oxidation and reduction peak at low scan rates. The slight asymmetry of the curve shows that the oxidation-reduction processes are not completely reversible. The addition of cobalt seems to be connected to the gradual flattening of the reduction peak as the scan rates increase. Adding cobalt also causes the oxidation peak to shift to a lower potential.

EIS results have shown that all samples exhibit a similar system resistance. The solvent molecule resistance to polarization is similar in all cases, because the electrolyte solvent was the same for all measurements. Increasing cobalt concentrations are connected with a higher electrical double layer capacity. Nickel hydroxide electrodes also exhibit a resistance to electron transfer on the electrode/electrolyte boundary that is higher than both the solution and polarization resistance.

It seems that coprecipitated cobanickel hydroxide can be used to make auxiliary electrodes with a high capacity. It has been observed that cobalt doping can reduce the effect that the parasitic OER reaction has on the electrode charging, these observations are in accordance with previous research.

Keywords: Cobalt doping, Nickel hydroxide, Coprecipitation, Auxiliary electrodes, Decoupled electrolysis

CLASSIFICATION OF RISKS ASSOCIATED WITH HYDROGEN INJECTION INTO EXISTING GAS DISTRIBUTION NETWORKS IN LATVIA

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ABSTRACT

Green hydrogen is a fuel of choice for the European Union (EU) energy future, and an energy carrier, which most likely will play an important role in its emerging energy security of supply strategies. Being fully dependent on large-scale green electricity production, as well as installed electrolysis capacities, green hydrogen will also be rather sensitive element of any such strategies. Thus, its versatility will unlock wide potential for energy sector integration as part of smart energy frameworks and, will contribute to the EU's energy transition.

Transition from natural gas and biomethane to green hydrogen will be gradual, and associated with two major categories of risks: methane rich fuel associated risks and non-methane rich fuel associated risks. The first category addresses solely the natural gas and biomethane related risks like leaks, fire, explosion and suffocation. The second category covers green hydrogen blended with methane and biomethane related risks. The safe share of hydrogen in a blend may range up to 10 % by volume, although this is a subject to ongoing debate. The main risk factors associated with high concentration of hydrogen in hydrogen-methane blends are: leaks, as hydrogen can diffuse through many materials considered impermeable to other gases, buoyancy as hydrogen rises quickly under atmospheric conditions, flammability when mixed with air, – can easily ignite or/and explode, hydrogen-induced cracking as reduction in the ductility of a metal can occur due to absorbed hydrogen (steels, iron, nickel, titanium, cobalt, and their alloys). Also, the energy content of hydrogen is about one-third of the natural gas. Thus, not only a large volume of the hydrogen-blended natural gas is needed to deliver the same amount of energy to users compared to pure natural gas but also a higher volumetric flow rate is required. Options for the latter include increasing operating pressure in a distribution system or replacing the existing pipelines with ones of larger diameter.

1.4. Fusion Energy, Nuclear Fission and Radiation Protection

COOPERATION IN THE DEVELOPMENT OF SMALL MODULAR REACTOR CONCEPTS

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ABSTRACT

Small Modular Reactors (SMRs) have many advantages, including shortened construction period, design simplification through standardisation, reduced upfront capital cost via modularisation, enhanced transportability, smaller emergency planning zones, suitability for non-electric applications, suitability for countries with small electricity grids, and flexible operation. Recognizing these advantages, numerous countries are actively engaged in the development of SMR prototypes. Notably, in November 2021, the European Commission supported an industry-led European SMR Partnership. This explains why SMRs introduction is planned in several EU countries and why Lithuania and Hungary may consider using them to produce electricity. The Lithuanian Energy Institute (LEI) and the Hungarian Centre for Energy Research (EK) responded to calls for bilateral projects issued by Lithuanian and Hungarian Academies of Science in 2022. The resultant project, titled "Contribution to the Development of Small Modular Reactor Concepts for the European Union," was accepted by both academies. During this three years project, the most promising SMR concepts and the main safety challenges related to employing passive safety systems for nuclear reactor cooling during accidents, investigation of critical heat transfer, and other issues will be analysed. The main goal of this joint research project is the establishment of cooperation between LEI and EK scientists, knowledge transfer and experience exchange through scientific visits. During this project, the processes in SMR will be identified, and later their numerical (potentially experimental) study conducted, which also will contribute to validating the computer codes and models.

This scientific communication will present the already performed work of both (LEI and EK) organisations. Within this bilateral project, EK brings valuable experimental and numerical expertise for the facilities PMK-2 and CERES. Among other processes the facilities are used for the analysis of the natural circulation process, which plays a key role in the safety of SMRs with the extensive use of passive cooling systems. Simultaneously, LEI has performed numerical investigations of the passive cooling system using 1D and 3D computer codes. The presentation also will discuss further activities in the project. This collaborative research and knowledge exchange initiative holds significant promise for addressing energy self-sufficiency challenges faced by scientific organizations in both Lithuania and Hungary.

Keywords: Small modular reactors, SMR, Safety, Feasibility

THE CODEX-ATF INTEGRAL BUNDLE TEST

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ABSTRACT

An integral bundle test was carried out in the framework of the IAEA Testing and Simulation for Advanced Technology and Accident Tolerant Fuels (ATF-TS) project in the CODEX (COre Degradation Experiment) facility. The test section included an electrically heated seven-rod bundle composed of 3 pieces uncoated and 4 pieces Cr coated optZIRLO cladding tubes. The main parameters of the scenario were selected on the basis of pre-test calculations.

Electrical heating with two tungsten heaters in each rod was applied. The heated length was 650 mm. The rods were pressurized during the test in order to reach ballooning and burst in the early phase of the experiment. The rods in the bundle were fixed by two spacer grids made of Zr1%Nb alloy. The bundle was placed into a hexagonal shroud. The shroud material was Zr2.5%Nb alloy, the total length of the shroud was 1000 mm. The bundle was heated by direct current power supply units. The steam generator provided hot steam to the test section. The water injection into the steam generator was performed with precision pump at constant flow rate. For heating up, argon gas was also injected into the steam generator.

In the preparatory phase the facility was heated up to 600 °C in 0.2 g/s steam and 0.2 g/s argon flow rates using both external heaters and fuel rod heaters. The heat-up phase continued with the same flow rates and with 1000 W heating power on the rods and 800 W power of external heaters. The rods were pressurised and cladding burst took place at ≈900 °C on most of the rods. The temperature increase was very smooth. At the initiation of water quench, the cladding temperature in the top of the bundle was above 1600 °C. In the upper part of the fuel rods 1400 °C was reached. It is expected that intense Zr-Cr eutectic formation took place at these temperatures. During the quench phase, room temperature water was injected to the bottom of the test section. The total hydrogen production was about 3 g, which indicated significant oxidation of the Zr components.

Keywords: bundle test, accident tolerant fuel, core degradation, VVER reactor

^{137}Cs AND PLUTONIUM ISOTOPIC "ZERO POINT" BASELINE ASSESSMENT IN EASTERN LITHUANIA: DETERMINING POTENTIAL RADIOLOGICAL IMPACT FROM ASTRAVETS NUCLEAR POWER PLANT

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ABSTRACT

Determining radionuclide concentrations and their isotopic shifts in the environment is a crucial step in detecting unusual nuclear pollution events and potential accidents in nuclear facilities and power plants. Radionuclides can travel hundreds of kilometers from their source with favorable air masses and can be detected in the air and deposited on the ground. Since the Astravets Nuclear Power Plant (NPP) became operational in 2020, it has become vital to establish long-term radiological monitoring in Lithuania. Conducting a baseline assessment of background "zero-point" radioactivity for existing anthropogenic radionuclides in the soil, originating from past nuclear tests and accidents, is essential to identify shifts in radiological impact and determine the potential contribution of anthropogenic radionuclide emissions from the Astravets NPP. In this study, various public places and spots were selected, and long-term radionuclide sampling points were established in Eastern Lithuania within a 70-kilometer radius around the Astravets NPP. Radionuclide radiochemical separation procedures, alpha-, gamma-, and mass spectrometric methods were combined. Gamma spectrometric measurements were conducted using state-of-the-art alpha spectrometry equipment, and gamma spectra were recorded using an HPGe coaxial detector, while the bulk plutonium content was measured with alpha spectrometry. Radionuclide isotopic ratios and their shift ratios were measured using the magnetic sector field "Element 2" mass spectrometer coupled with the high-sensitivity APEX sample introduction system. The findings revealed that fallout from previous Cold War-era nuclear weapons tests predominated in most of the sampling sites. "Zero-point" baseline concentrations of 137Cs and Pu were determined, and isotopic "fingerprints" such as 137Cs/239,240Pu, 238Pu/239,240Pu, and 240Pu/239Pu were documented for long-term radiological impact monitoring.

Keywords: 137Cs, Plutonium, Radionuclides, Radioecology, Gamma Spectrometry, Mass Spectrometry, Radiological Preparedness, Radiation Protection, Astravets Nuclear Power Plant

MODELLING OF NSR SAFETY RELEVANT RADIONUCLIDE SORPTION IN LOAM OF DIFFERENT MINERALOGICAL COMPOSITION

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ABSTRACT

While performing a safety assessment for radioactive waste disposal or storage facilities, it is necessary to carry out an evaluation of the engineered and natural barrier capability to prevent radionuclides migration into the environment. Generally, radionuclide retardation is evaluated using a generalised coefficient Kd for radionuclide retention. This approach to evaluate radionuclide migration can provide an insight into radionuclide behaviour when interacting with various materials, however it does not accurately represent the processes during this flow. In order to achieve a more accurate representation of these processes, computer models can be developed with more accurate interactions of radionuclides with materials represented.

Sorption is modelled as the combination of the surface complexation and cation exchange reactions. These reactions are dependent on the mineral (i.e. cation exchange capacity (CEC) of the studied material, number of surface sites, etc.). The available measurements data provides total CEC of the soil and CEC of different minerals is not distinguished. This study presents the modelling of the radionuclide sorption with the surface complexation and cation exchange reactions in near surface repository (NSR) environment (natural loam barriers) using two different approaches. The first approach assumes, that the cation exchange reactions are taking place on illite and surface complexation reactions occur on both illite and kaolinite in the clay. The second approach takes into account the more complex nature of loam mineralogical composition and surface complexation and cation exchange reactions on both illite and kaolinite are taken into account. It is considered that the total soil CEC is the sum of the CEC of the different minerals. Summation method is used to determine the individual CEC from the total soil CEC for the purposes of modelling of radionuclide sorption. Radioactive nickel was selected for the investigations as it has a long half-live, is well-sorbed, present in the waste generated in nuclear power plants and is safety relevant radionuclide. Sorption was modelled for pH range from 2 to 12. The sorption of Ni is measured by sorption isotherms, determining the amount of aqueous Ni from the solution being sorbed on the clay minerals.

The modelling results indicated that the largest difference in modelled sorption values between the cases was at pH 4, where difference of 12.7% between results is obtained. In the characteristic pH levels for clayey soils (around 7.5-10 pH range), this difference is slightly lower (7.7% at pH 8 returning to 9.7% at pH 9, where the numerical difference is higher). In the first case, the amount of sorbed Ni was on average 10.2% lower than in the second case when more detailed summation method was implemented. However, the overall patterns of sorption in both cases follow the same trend. The more detailed sorption model can be used where complex nature of the soil should be taken into account. However, such model requires additional input data about the soil composition and properties. Therefore, for initial radionuclide sorption assessment and in the case of limited data about the soil, the simplified model could be sufficient. In addition, for the large modelled system (e.g. at repository scale) and long time-frames the simplified model could save calculation resources.

Keywords: radionuclide, radioactive waste repository, sorption.

ROLE OF B_4C AND GD_2O_3 IN POLYANILINE COMPOSITES AS NEUTRON SHIELDING MATERIAL: A SIMULATION STUDY

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ABSTRACT

There it is a need for radiation shielding due to nuclear energy production and nuclear applications. Neutrons, unlike alpha and beta particles, have no electric charge; unlike gamma rays, they have mass. Therefore, their material interactions differ from those of charged particles and gamma rays. While gamma rays primarily interact with orbital electrons, neutrons interact with the atom's nucleus. The complex penetrating ability of the neutrons requires unique shielding materials. Polymers are widely used due to their low cost, versatility, precise controllable synthesis, and ability to be easily obtained, which makes them suitable for radiation shielding. Additives have a vital role in changing the shielding characteristics of the polymer (1). Polyaniline (PANI) offers excellent electrical conductivity, high-temperature resistance, and long-term environmental resilience. The literature reveals polyaniline has not been extensively investigated as a potential neutron-shielding material. Thus, the applicability of polyaniline composites containing gadolinium oxide (Gd_2O_3) and boron carbide (B_4C), which contain Gd and B with high microscopic cross sections, in neutron shielding, was investigated. A simulation study for thermal (0.025 eV), epithermal (1 keV), and fast (4.5 MeV, 10 MeV, 20 MeV) neutrons was performed by Geant4. First, simulations were carried out for composites with 15%, 30%, and 60% B_4C by weight added to PANI. The highest neutron attenuation was determined for the PANI/B_4C (60%) composite. Subsequently, the simulations were carried out by adding Gd_2O_3 at weights of 2%, 4%, 6%, and 8% to the selected PANI/B_4C composite. The macroscopic cross-section (Σ) and half-value layer (HVL) were calculated by theoretical calculations and Geant4 simulations (Fig.1). While the macroscopic cross-section values of PANI were 1.7 cm^{-1} for thermal neutrons, 1.2 cm^{-1} for epithermal neutrons and 0.10 cm^{-1} for fast neutrons, the macroscopic cross-section values of composites ranged between 40.7 cm^{-1} to 76 cm^{-1} for thermal neutrons, 1.36 cm^{-1} to 1.53 cm^{-1} for epithermal neutrons, and 0.16 cm^{-1} to 0.18 cm^{-1} for fast neutrons. HVL values varied between 0.01 cm and 0.02 cm for thermal neutrons, 0.45 cm and 0.51 cm for epithermal neutrons, and 3.80 cm and 4.31 cm for fast neutrons. Adding boron and gadolinium increased neutron attenuation, especially for thermal neutrons. PANI composites offer a wide range of possible applications as reliable shielding materials in nuclear-related industries and could be an acceptable replacement for existing shielding materials.

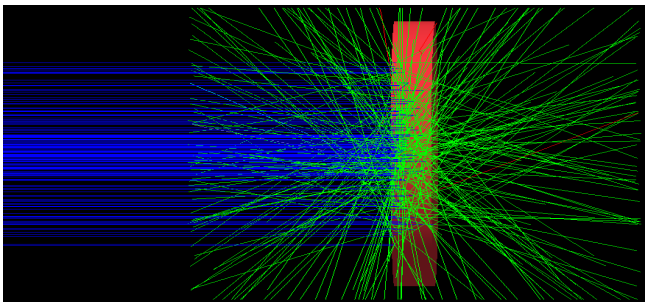

Fig.1: A representative Geant4 simulation at 0.025 eV.

Keywords: polyaniline, boron, gadolinium, neutron shielding, attenuation, Geant4

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FLAW HANDBOOK DEVELOPMENT FOR NPP VVER-1000 RPV BELTLINE ZONE WELD #4

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ABSTRACT

Non-Destructive Examination (NDE) In-Service Inspection (ISI) results in flaws detection, schematization and sizing, namely: equivalent area, length, height or combinations. Fracture mechanics calculations results are presented in comparison with the acceptance criteria whether the specific crack is acceptable/allowable or not for NPP equipment or pipe specific component operation. To reduce the scope of NDE ISI without reducing the NPP safe operation level, it was proposed to develop the concept for linking ISI results and fracture mechanics calculations to enable NPP ISI staff with effective utilization of existing ISI systems/manual NDE and future NDE development planning. A criterion is based on conception of critical, acceptable and allowable flaw sizes. These sizes are determined based on fracture mechanics analysis and crack growth rate evaluation. The ASME Section XI to address second criterion formulation is considered. The best international practices provide the way for NPP personnel to simply using the data on acceptable and the allowable crack sizes for specific equipment. It is the concept of the Flaw Evaluation Handbook for Future Service without Repair.

In this talk all the steps of the above procedure are realized to develop the Flaw Handbook for the NPP VVER-1000 reactor pressure vessel (RPV) beltline zone weld #4. As a limiting emergency condition, the transient step cool down scenario was considered. In accordance with such a scenario, the coolant temperature is dropped immediately from the normal operation temperature to the selected limiting values. For the RPV region, the most conservative value is the hydraulic tanks water temperature of the Emergency Core Coolant (ECC) system. At the same time, primary circuit pressure is not reduced and is equal to the normal operating pressure value. Conservative value of the heat transfer coefficient should be applied. Such a scenario has a maximum available conservatism from the point of view of cool-down rate and pressure value. We consider the “hydro test - heat up - cool down” normal operation cycle. This cycle is used for calculation of crack growth during unit operation. Real data obtained during NDE ISI performance from NPP were used for our calculations. For the determination of critical/acceptable crack sizes only the worst case of the emergency conditions was considered. The linear-elastic model of the material behavior was applied. Cracks of two orientations were postulated. Determination of critical crack sizes was performed using fracture mechanics calculations. With this aim, the conditions of critical crack size were determined. For calculations, the RPV material properties from VERLIFE code were used. The acceptable and allowable crack depths were determined for each crack parameters ratio.

Also developed the recommendations for Flaw Handbook utilization. Some of the diagram forms are simpler in using to define flaw allowability etc. that can be used to determine time left to upcoming necessary weld repair.

Keywords: Non-Destructive Examination; In-Service Inspection; Flaw Handbook; critical crack size; acceptable crack size; allowable crack size; fracture mechanics

1.5. Energy Efficiency, Reliability and Security

LITHIUM-ION BATTERIES AGEING MODELLING AND RELIABILITY ASSESSMENT METHODS

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ABSTRACT

This research delves into the evolving landscape of lithium-ion battery ageing methods and models, underscoring their significance in the context of renewable energy, electric vehicles, and consumer electronics. Lithium-ion batteries, marked by their impressive energy retention and technological diversity, have progressed from basic rocking chair models to intricate systems incorporating advanced anodes and electrodes. However, challenges such as high initial costs, safety risks, and material bottlenecks necessitate an in-depth analysis of battery ageing to optimize performance and lifespan.

The study is grounded in a comprehensive analysis of scientific literature over nearly three decades. It categorizes ageing models into four distinct groups: physics-based methods (PBM), equivalent circuit methods (ECM), empirical and semi-empirical methods (EM), and machine learning methods (MLM). Each model's development, application, and efficacy are examined, providing a historical perspective on their evolution and a comparative analysis of their strengths and weaknesses.

Findings reveal that each model category offers unique advantages and faces specific challenges. PBMs are precise in simulating internal chemistry but are computationally demanding; ECMs offer ease of use but may not accurately predict long-term ageing effects; EMs are straightforward yet limited by their parameter reliance; MLMs excel in handling complex relationships but require substantial data and can be uncertain in their predictions. The study also highlights the shift towards integrating real-life usage data for more accurate battery ageing forecasts.

The study concludes that a holistic approach combining different modelling methodologies is essential for a comprehensive understanding of lithium-ion battery ageing. While physics-based models provide detailed insights into internal battery mechanisms, machine-learning models offer predictive power in real-world applications. The future of battery ageing models lies in their hybrid cases and integration into battery management systems for enhanced real-time monitoring and predictive analysis, contributing significantly to the development of more efficient and sustainable battery technologies.

Keywords: lithium-ion batteries, battery ageing models, battery performance optimization, safety risks, battery management systems, sustainable battery technology.

VALIDATION OF PHPP AND ESBO LIGHT TOOLS BASED ON LOW-ENERGY BUILDING MONITORING DATA

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ABSTRACT

The main aim of the study is to determine the operational heat consumption of the building and to compare it with the simulated results obtained during design. The study analyses the heat pump electricity consumption for heating and hot water of the building and the building's internal temperatures collected from 2016 to 2020. The simulation tools are used – the Passive House Design Package (PHPP) and Swegon ESBO light. The validation of the software is carried out during the study. A comparison of the data obtained showed a close correlation between the results of the two cases. The results obtained by the software were also consistent with those measured during the building operation. The study's conclusions confirm the appropriateness of using PHPP in the design process and contribute to increasing confidence in modelling the annual thermal energy consumption of compact buildings.

Keywords: simulation tools, electricity, heating, consumption, Passive House, validation.

EXPERIMENTAL INVESTIGATION ON A SERPENTINE CONDENSING HEAT EXCHANGER

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ABSTRACT

Industrial processes often generate significant amounts of waste heat. Recovering and utilizing this waste heat presents a crucial strategy for improving resource efficiency and reducing environmental impact. This study explores methods to optimize waste heat recovery through condensation processes. The research leverages the framework of the Innovative WAter recoverY Solutions through recycling of heat, materials, and water across multiple sectors (iWAYS) project. Within this framework, researchers at the Lithuanian Energy Institute (LEI) Nuclear Engineering Laboratory (NEL) conducted experiments using a serpentine heat exchanger. The heat exchanger has two fluids: hot, humid air (with varying steam content) around the serpentine and cold municipal water flowing through the serpentine.

The experiments focused on understanding the impact of two key variables on condensation efficiency: inlet temperature of the humid air (ranging from 80°C to 200°C) and the mass fraction of steam within the air (varying from 10% to 20%). By systematically altering these parameters, the researchers aimed to gain insights into how fluid behavior and condensation efficiency are influenced. Key findings suggest that increasing the mass fraction of humid air decreases the temperature difference between inlet and outlet, indicating reduced heat exchange. Higher mass fractions lead to increased condensation rates, while higher inlet temperatures result in decreased condensation rates. Moreover, higher mass fractions are associated with increased condensation efficiency, whereas higher inlet temperatures correlate with decreased condensation efficiency.

Finally, the research highlights the importance of both inlet temperature and mass fraction for optimizing the design of a condensing heat exchanger. By adjusting these parameters, engineers can influence heat exchange, condensation rates, and overall efficiency. These findings contribute valuable insights for industrial applications seeking to optimize waste heat recovery through condensation processes.

Keywords: Waste heat recovery, heat exchanger, condensation, condensation efficiency

A REVIEW OF HEAT TRANSFER ENHANCEMENT METHODS USED IN INDUSTRIAL HEAT GENERATION FACILITIES

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ABSTRACT

Industry can improve it's competitiveness, resilience, and social responsibility by adopting technological sustainability. Ensuring economic growth that is inclusive and sustainable is fundamentally linked to the principle of energy efficiency. Industrial heat energy generation facilities used as heat sources for various industrial processes and their efficiency depends on the type of fuel, technology, and process used, including the temperature level required. Various types of technologies and measures can improve the heat transfer efficiency and reduce the emissions produced by industrial heat generation. Enchantment of heat transfer efficiency in such facilities is one of possibilities to ensure systems operate in a suitable mode. Heat transfer enhancement techniques in various industries have been the focus in many research studies. Passive methods, such as the use of inserts, porous materials, and rough surfaces, have gained attention due to their cost-effectiveness and ability to improve heat transfer rates without requiring additional power. Active methods, including electric fields, magnetic fields, and ultrasound, have also been explored. Passive heat transfer enhancement techniques' aim is to improve the thermal performance of energy conservation systems without the need for additional power input. Various passive methods have been studied, including the use of inserts such as twisted tapes, conical strips, baffles, and winglets, as well as extended surfaces like fins, porous materials, coil/helical/spiral tubes, rough surfaces, and nanofluids. Studies have demonstrated that these methods are economically beneficial and dependable, leading to reductions in energy consumption and enhancements in the thermal performance of heat generation systems. The use of passive techniques can enhance heat transfer rates and improve the overall performance of heat exchangers.

In this paper, it is reviewed main types and benefits of using turbulators. Main feature of turbulators are to create swirls and secondary flow, in general to increase heat transfer by convection. This paper reviews the works pertaining to the application of different class of tube inserts in order to comprehend the prevailing mechanism of fluid flow and heat transfer. Our purpose is to find out whether other authors estimate the increase in heat transfer due to radiation when there are used inserts in heat exchanger tubes.

Keywords: heat transfer enhancement techniques (THE), turbulator, fire tube, radiation, inserts, heat transfer

DATA-DRIVEN ANALYSIS OF BUILDING MODERNIZATION FOR ENHANCED ENERGY EFFICIENCY AND DECARBONIZATION OUTCOMES

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ABSTRACT

The modernization of existing buildings is pivotal in achieving energy efficiency and decarbonization goals. This process necessitates a careful balance of various factors, such as thermal insulation parameters, HVAC system efficiency, and others, to optimize results. A primary challenge encountered is the discrepancy between projected and actual performance parameters following modernization. Additionally, the multitude of parameters involved often includes elements that do not significantly contribute to energy efficiency. These issues raise important scientific questions about which criteria most effectively enhance energy efficiency and which might not be cost-effective.

This manuscript provides an analysis of historical data, contrasting projected parameters with actual post-modernization performance, and assesses the improvements in energy efficiency that result. Our aim is to pinpoint the list of criterias that most significantly affect energy efficiency. The insights derived from this study will aid in developing a mathematical model. This model is intended to predict the most influential criteria based on specific building characteristics, thereby directing future modernization efforts towards more impactful and efficient outcomes.

APPLICATION OF MACHINE LEARNING FOR THE ANALYSIS ULTRASONIC SIGNALS OF IN-SERVICE INSPECTIONS OF THE REACTOR PRESSURE VESSEL

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ABSTRACT

In the operation of a nuclear power plant, ensuring operational safety and exploring ways to extend its lifespan is paramount. Non-destructive testing is critical in assessing product quality without causing damage, utilizing radiation for inspection. The in-service inspection of the base metal and welds is vital for providing insights into the reactor's current condition. Neglecting timely detection of defects might lead to leaks of radioactive substances or other accidents, posing risks to both personnel and the environment. Consistent safety checks of the reactor and its components are imperative to avert such irreversible incidents. The reactor pressure vessel, being a welded structure, is particularly vulnerable to the occurrence of the defects. Throughout a nuclear power plant's operation, the reactor pressure vessel's material undergoes significant stress due to exposure to high neutron fluence, pressures, and temperatures, potentially causing cracks. A crack is one of the most dangerous defects in the reactor pressure vessel. The most effective way to measure such a defect is the time-of-diffraction (TOFD) technique, during which diffraction signals are received from the edges of the defect, making it possible to determine its height quite accurately and make further decisions about the reactor's operation.

Interpreting TOFD ultrasound signals can be challenging. The complexity is heightened by austenitic cladding on the inner surface of the reactor pressure vessel, which enhances the noise resolution and makes the signal analysis process even more intricate, even for seasoned experts. Thus, to improve the accuracy of in-service inspection outcomes, it is advisable to use modern data processing methods, in particular machine learning methods.

We have built a machine learning model for TOFD and, in particular, for investigating defects on the reactor pressure vessel through the austenitic cladding. The neural network training dataset was generated and simulated in CIVA software [1], [2]. As a result of this study, after selecting the hyperparameters on the test data set, the average absolute error in determining the crack height was 0.5 mm, and the average absolute error was 5%. The purpose of such research is to ensure the maximum similarity of the researched object to the reactor pressure vessel, for the possibility of future use in real conditions.

Keywords: reactor pressure vessel, safety, time-diffraction technology, machine learning models.

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1.6. Energy Economics and Policy

HOW THE ADOPTION OF EU CLIMATE POLICY AFFECTS NATIONAL COMPETITIVENESS: UNVEILING STRATEGIES AND POLICY INSIGHTS

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ABSTRACT

Europe's ambitious goal of becoming the world's first climate-neutral economy by 2050 while simultaneously maintaining global competitiveness undoubtedly sets new directions and poses distinctive challenges for the development of national economies and policies. Economies are currently facing various geopolitical and economic turbulences, such as the Russia-Ukraine war, energy crisis, supply chain disruptions, technological unreadiness, and skills shortages, so strengthening the competitiveness of the EU as a whole and individual member in alignment with European Climate policy is indeed a complex challenge. Considering that a significant portion of the greenhouse gas emission reductions rely on technologies that are not yet ready for the market and behavioural changes of communities and individuals in tackling environmental challenges are still limited, there is a need for more systematic research into how place specificity and scale influence green transition processes. There is a gap in understanding how the adoption of EU climate policy impacts the competitive metrics of individual EU members and how changes factors, having the greatest impact on national competitiveness. The new knowledge can inform the development of more effective competitiveness, industrial and energy policies, particularly in turbulent scenarios.

The research uses the definition of green competitiveness, which covers the net green approach and incorporates economic and environmental trade-off aspects into competitiveness at the national level.

Empirical research was conducted on the basis of 24 EU countries over a 10-year period (2012–2021). Construction of the competitiveness index and comparison with CO_2 emissions, as well as use of clusterization and principal component analysis methods, allowed the identification of five dominant green competitiveness strategies in the EU and the main factors that have the greatest impact on national competitiveness within each dominant strategy. The research has proved that the concept of green competitiveness is contingent upon place specificity. It posits that the benefits derived from increases in green competitiveness are enduring and consistent; however, the factors influencing competitiveness and the time period required to achieve this goal may vary. The results of the research are useful to policy makers in making decisions on competitiveness, industrial, and energy policies.

Keywords: European Climate policy, Competitiveness factors, Carbon dioxide, Industrial and Energy policies.

ENRON NATURAL PONZIS AS A RESULT OF FINACIAL SATURATION PHENOMENON

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ABSTRACT

Most experts believe that a pyramid of financial fraud and false accounting caused the Enron bubble and its collapse. We support the alternative view that the bubble's root cause was a natural Ponzi. As we know, financial pyramids do not to create bubbles. They tend to keep yields artificially high in order to attract new investors. A bubble forms when large financial resources are concentrated in a saturated market. The initial subdued economic growth is then amplified by feedback loops, triggering an economic rebound. This leads to an improvement in the company's financial performance, creating an illusion of stable financial prosperity and eventually ends in crisis. Schiller in Irrational Exuberance called this phenomenon a natural Ponzi. Although Schiller did not directly assess the phenomenon of saturation, he did observe the bubble phenomenon and linked the feedback loop effect to irrational investors' behaviour.

Crises have been happening for centuries, but economists have largely ignored financial bubbles. Financial bubbles only came to serious attention after the 2008 crisis. This means that the Enron crisis unfolded at a time when economists' perception of bubbles was still insufficient. As a result, the 2001 Enron scandal has been attributed entirely to fraud and illegal actions by the company's management.

A natural Ponzi takes shape in stages. In the initial stage, when the financial bubble is just beginning to inflate, the company's financial indicators start to improve, its management misjudges the situation, its executives feel over-optimistic, and later perhaps even euphoric. They feel that this growth is due to their exceptional skills and is sustainable. In the next stage, they start to waste, squander company resources, and in the final stage, as the situation worsens, they start to commit fraud.

A logistic analysis of Enron, using the Loglet model, revealed a hyperbolic increase in the share price due to capital saturation. As a result, the company's management started to spend and expand its business into other areas. As a result, profitability fell. The management wanted to maintain the status quo of the company. However, when things did not improve management resorted to deception and fraud. As a result, Enron's activities may be seen as a natural Ponzi scheme. A successful analysis of the Enron crisis would help to prevent a bubble in the future, for example in the green, renewable energy and other sectors.

Keywords: financial saturation, natural Ponzis, bubble, Enron

ECONOMIC IMPACT OF ENVIRONMENTALLY FRIENDLY PRACTICES: A SYSTEMATIC LITERATURE REVIEW AND FUTURE RESEARCH DIRECTIONS

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ABSTRACT

In an era marked by heightened awareness of environmental challenges and a pressing need for global sustainability, environmentally friendly practices have become paramount. These practices signify a fundamental shift in how businesses, governments, individuals, communities, and societies approach the acquisition, use, and disposal of goods and services. They entail making choices that minimize adverse environmental impacts, promote social responsibility, and contribute to long-term ecological balance.

This systematic literature review delves into the evolving landscape of environmentally friendly practices, identifying industries, methods for analyzing impact, and types of environmentaly practices impact on economy. Furthermore, it critically examines current research to offer insights into the dynamic nature of sustainable development. Additionally, this research outlines a future research agenda, highlighting areas that warrant further investigation to deepen our understanding of the subject and contribute to advancing sustainable consumption practices and their effects on the economy.

Keywords: Environmentally friendly sustainability practices, economic impact, economic effects

GEORGIAN POWER SYSTEM 2030: PLEXOS SIMULATION OF SOLAR AND WIND INTEGRATION, MARKET DYNAMICS, AND GENERATION ADEQUACY

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ABSTRACT

Since 2019, Georgia's electricity market has experienced changes in order to comply with European rules and regulations. The nation's dedication to a dynamic energy sector is reflected in 3 operational market segments to be implemented in 2024: bilateral contract, day ahead/intraday, and balancing and ancillary services market. In addition, according to the 10-year network development plan, Georgia is also seeing an increase in variable renewable energy (VRE), mostly wind and solar.

This study uses PLEXOS modeling to forecast the integration of 1200 MW wind and 500 MW solar power facilities (VRE high penetration to power system) by 2030, assessing their impact on wholesale market dynamics. The focus is on understanding the challenges caused by VRE intermittency and instability, offering valuable insights applicable to regulators and policymakers across the world in similar contexts.

The study advances theoretical understanding by introducing innovative methodologies within the PLEXOS model, which integrates both candidate and existing power plants, incorporating their technical and financial parameters. Machine learning techniques provide detailed analyses, including power consumption prediction, capacity reservation, and system balancing. The findings not only underscore the crucial role of hydroelectric generation but also give significant contributions from wind and solar sources.

In addition, the study underlines the broader applicability of its findings by highlighting parallels between Georgia's energy sector and that of other developing countries undergoing energy transitions. Practical implications are highlited, demonstrating how insights gained from the study can inform decision-making processes, shape policy interventions, and guide investment strategies in diverse regional contexts.

In conclusion, the integration of VREs has an important effect on the Georgian power system and electricity market. The study shows the necessity for proactive steps to manage peak demand concerns by highlighting the negative effects of energy not served on the economy and the environment. As renewable energy becomes more prevalent in the energy mix, there is a general trend toward lower costs, which is supported by the integration of solar and wind energy, which shows a beneficial impact on short-term marginal costs.

Keywords: Electricity Market Dynamics, Renewable Energy Integration, Ten-Year Network Development Plan, System Adequacy, Short-Run Marginal Costs (SRMC), Energy Not Served.

ANALYSIS OF POWER-TO-HYDROGEN INTEGRATION TO DISTRICT HEATING MARKET

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ABSTRACT

The energy sector is currently experiencing a massive transformation, leading to a sharp increase in the share of intermittent renewables, such as solar and wind, which can lead to significant curtailment or surplus of energy production. The expansion of intermittent renewables also raises operational and balancing issues. District heating (DH) can play a significant role in preventing massive power production curtailments by incorporating new technologies for balancing supply and demand in energy systems. However, the whole energy sector transformation requires incorporating advanced energy solutions such as Power-to-X, demand response and other flexibility and storage technologies in order to have synergy, decarbonization, and economic efficiency. The essential economic effect is expected to occur by integrating hydrogen generation technologies in the DH sector due to the flexibility to use surplus renewable electricity and the ability to recover hydrogen waste heat into heat networks. New hydrogen plants with heat pumps and storage tanks may pose a major challenge to the heat market. The investments by the DH operator in advanced hydrogen technologies would have an impact on the economic and financial performance of local independent heat producers, which may have both positive and negative effects in the future. Therefore, a new approach should be investigated through a comprehensive literature review and practical research aiming to show how these innovative solutions influence the heat sector market and how the ongoing market changes may affect city heat producers and final heat consumers. The main innovation of this work is a new methodological approach for DH sector integrating a deterministic approach with uncertainty and sensitivity analysis. SimLAB software dedicated to Monte Carlo analysis and EnergyPRO, used to implement the deterministic approach, will play an important role in the comprehensive analysis of the research analysing the potential impact on the selected DH network market players. The methodology developed offers a huge potential for the use of waste heat from hydrogen production in DH networks due to the relatively low variable marginal heat prices and the potential competition against other market players in the local DH network.

Keywords: District Heating, Power-to-X, Hydrogen, Waste heat recovery, Heat Market

1.7. Bioenergy, Biomass and Biofuels

NITROGEN FIXATION AND ROOT NODULATION EFFICIENCY OF LITHUANIAN *PISUM SATIVUM* VARIETY "EGLE DS" AFTER SEED INOCULATION WITH DIFFERENT *RHIZOBIUM* SPP.

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ABSTRACT

Rhizobium is the well-known nitrogen-fixing symbiont of legume plants. In the realm of agricultural practices and enhancement, the use of rhizobia inoculants emerges as a highly effective, environmentally friendly, and economically viable alternative for achieving optimal agricultural productivity. However, different rhizobia strains have different nitrogen fixation efficiency. In this study, 20 Rhizobium spp. isolates, obtained from five pea (*Pisum sativum*) genotypes (Bagoo, Respect, Astronaute, Lina DS, and Egle DS) were selected for Lithuanian pea variety "Egle DS" seed inoculation. *Rhizobium* spp. inoculation effects on nitrogen fixation and root nodulation was tested under sterile and climate-controlled conditions. Not inoculated plants were used as control. A number of root nodules and total nitrogen content in pea shoots were evaluated. Results showed that all *Rhizobium* spp. isolates significantly increased nitrogen content in the plant, compared to the control, but different isolates demonstrated different efficiency on pea root nodulation and nitrogen accumulation in plant biomass. The highest nitrogen accumulation was achieved where EGLE07, BAGOO07, EGLE05, ASTR08, and LIN03 isolates were inoculated; the nitrogen content was 4.82-fold, 4.81-fold, 4.73-fold, 4.54-fold, 4.33-fold higher respectively, comparing to the control. The most intensive nodulation was found where RSP08, BAGOO07, LIN08, LIN04, and EGLE05 isolates were inoculated; the average number of nodules on pea roots was 83, 81, 78, 77, and 75 unit plant-1, respectively. The number of nodules between the investigated Rhizobium spp. isolates did not differ significantly. No correlation was found between nitrogen accumulation in plant and the number of nodules.

Keywords: Nitrogen; *Rhizobium* spp.; *Pisum sativum*; Pea; Nodules

A LIFE CYCLE ASSESSMENT OF METHANE SLIP REDUCTION IN BIOMETHANE PRODUCTION PROCESS

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ABSTRACT

Biomethane purification in biogas obtained from an anaerobic digestion process can be performed through CO_2 removal by several biogas upgrading technologies, such as water scrubbing, chemical scrubbing, physical scrubbing, pressure swing adsorption, membranes separation, cryogenic liquefaction and others. However, most technologies still have off-gas flow, consisting of a small amount of methane. This methane lost with off-gas is called methane slip, thus increasing greenhouse gas emissions into the atmosphere. In this study, a life cycle assessment (LCA) was conducted, and a sensitivity analysis for different methane slips in off-gas was carried out.

The LCA is a methodology for comprehensively assessing the environmental impact associated with a product or process throughout its life cycle, applying boundaries for the system cradle-to-grave analysis. In this research, the environmental impact we performed on the permeable membrane technology for biomethane production. This technology was analysed using the framework of the LCA methodology and referring to the cradle-to-grave analysis. A cradle-to-gate perspective can be applied when the system boundaries are restricted to selected life cycle stages. In this research, we analysed and discussed the environmental impact of the permeable membrane technology for biomethane production only. So, the gate-to-gate boundaries were applied.

The research showed that higher methane content in biogas reduces methane slip in membrane upgrading technology (Fig. 1). However, energy consumption rises when biogas upgrading is set for higher methane upgrading efficiency.

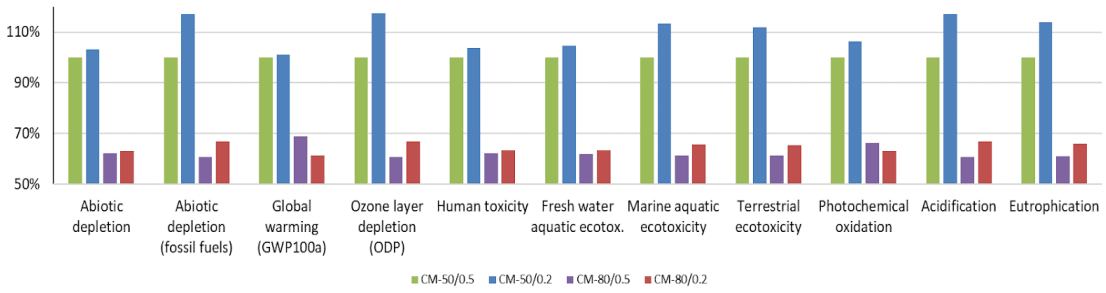

Figure 1. Environmental impact in impact categories at different methane slip

We concluded that lower methane slip could mitigate environmental impact despite the rise in the need for electrical energy in biogas upgrading when the initial methane concentration in the biogas rises.

Keywords: methane concentration, biogas upgrading, membrane separation, methane slip, biomethane production efficiency, life cycle assessment of biomethane.

BIOMASS PRODUCTIVITY AND ENERGY EFFICIENCY OF MAIZE, HEMP AND FABA BEAN MULTI-CROPS

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ABSTRACT

Crop biomass energy is becoming an increasingly common alternative energy source, such as wind or solar energy. Currently, maize, hemp, faba bean and other agricultural crops have one of the highest biomass productivity, nutritional and energy potential in Lithuania. The cultivation of these crops produces not only the main nutritional and/or feed products (grains, seeds), but also secondary products such as harvesting waste, which can be used for energy purposes.

A stationary field experiment was carried out in 2020–2022 at the Experimental Station of Vytautas Magnus University, Agriculture Academy, Lithuania. In our research, under the conditions of sustainable agriculture, the scope of the experiment was expanded, not only single and binary crops were studied, but also a ternary maize, hemp and faba bean multifunctional energy crop, in which maize played the role of abundant biomass producer, hemp played the role of biomass producer and protection against diseases and pests, faba bean - the role of the provider of ecological services in agrocenosis.

The highest total dry biomass per unit area was produced by the ternary crop, although the highest green biomass was produced by the single–crop of maize. The highest fuel and energy consumption was found in the ternary crop, as the sowing and harvesting operations were carried out in two machine passes. The higher costs were compensated by the higher biomass productivity of the ternary crop. The net energy of the ternary crop was 1.9–5.3 times higher than that of the other crops grown.

Keywords: *Zea mays* L.; *Cannabis sativa* L.; *Vicia faba* L.; multicropping; biomass; energy.

YEAST-POWERED MICROBIAL BIOFUEL CELLS WITH QUINONES AS MEDIATORS

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ABSTRACT

The global warming and climate change necessitates the exploration of alternative energy sources to replace fossil fuels, which now are the predominant energy source. Fossil fuels release substantial quantities of greenhouse gases, possess finite reserves, and experience price volatility. Given the negative effects of using these energy sources, such as running out of energy, resources, and harming the environment, it is imperative to either make current energy conversion technologies more efficient or switch these energy sources to renewable ones. Biofuel cells might be one of these energy sources. One of them is a microbial fuel cell (MFC), electrochemical device that utilizes the catalytic capabilities of living microorganisms to directly transform the chemical energy of organic compounds into electricity by oxidizing the organic components. Yeast cells are readily available and well-suited for redox-active microorganisms that are important for MFCs. Nevertheless, the generation of this "bioelectricity" is limited by charge transfer through the yeast cell membrane and cell wall. The resolution of this problem can be achieved by choosing of appropriate charge transfer mediators. For this, a two mediator-based redox system is usually applied: one redox mediator is lipophilic and can penetrate the cell membrane and interact with the intracellular redox centres; another mediator is hydrophilic and accepts electrons from the lipophilic mediator and passes them to the electrode. Quinones were chosen as lipophilic mediator, and hexacyanoferrate as hydrophilic mediator. Quinones engage with the oxido-reductase systems of the plasma membrane, which can be reached from the periplasm of the cell. Further the charge is transferred by hexacyanoferrate. The main aim of our studies is to evaluate the effectiveness of microbial fuel cells using different quinones as redox mediators.

Keywords: Microbial fuel cells, Mediator, Yeast, Biofuel Cell

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IMPACT OF LONG-RANGE TRANSPORTED BIOMASS BURNING-RELATED BLACK CARBON IN TWO URBAN ENVIRONMENTS

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ABSTRACT

Biomass burning is identified as a major source of atmospheric pollution giving rise to the release of large quantities of aerosol black carbon (BC). The present study aims to analyse the impacts of biomass burning on BC loading over the urban areas of Vilnius and Warsaw, two neighbouring capital cities, and the effect of long-range transported pollution between the two cities. Properties of light-absorbing aerosol particles and a novel approach to assess the impact of long-range transport on black carbon (BC) pollution are presented. Aerosol BC mass concentration was measured using Aethalometers (AE33, Magee Scientific); aerosol scattering properties were recorded using Nephelometer (TSI model 3563 in Vilnius and Ecotech, model Aurora 4000 in Warsaw). The changes in BC source contribution, light absorption coefficient, absorption and scattering Ångström exponents (AAE and SAE, respectively), and single scattering albedo (SSA) were investigated from May to August 2022. The BC source apportionment to biomass burning (BC_{BB}) and fossil fuel combustion (BC_{FF}) showed similar contributions for both sites with BC_{BB} (13–19%) being significantly lower than BC_{FF} (81–87%). The mean SSA was very low (0.69 ± 0.1 in Warsaw, 0.72 ± 0.1 in Vilnius). The local episodes of extensive biomass burning due to celebrations of May Days on 1st - 3rd May in Warsaw and Midsummer on 24th June in Vilnius showed similar aerosol properties in both cities but were highly different than any other during the entire campaign. Moreover, these extensive biomass burning events resulted in an increased aerosol light absorption and decreased SSA which have a warming effect on the atmosphere. The results provide a better perception of the biomass-burning-related aerosol characteristics in the ambient atmosphere.

Keywords: Biomass Burning, Solid Biomass Fuels, Fossil Fuel, Black Carbon, Long-range transport.

Acknowledgement: Funding received by joint Lithuanian-Polish research project DAINA-2 grant "Importance of long-range transport of BIOmass burning emissions to local Smog events in Urban Environments (BIOSURE) supported by National Science Centre of Poland (Narodowe Centrum Nauki) (Grant no. 2020/38/L/ST10/00480) and the Research Council of Lithuania (Lietuvos mokslo taryba) (Grant no. S-LL-21-7).

INVESTIGATION OF MULTI-CROP PLANT BIOMASS ASH PROPERTIES

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ABSTRACT

Ash content and ash melting characteristics are important criteria determining the quality and suitability of biomass pellets for solid biofuel. Low ash melting temperatures can cause slagging and hard-to-remove deposits in the incinerator. The maximum permissible amount of ash is defined by the quality standards of the pellets. Compared to wood biofuel, burning herbaceous and other non-woody plants produces larger amounts of ash, which can reach 8–10%. Multi-crop biomass can be a viable source of solid biofuels. The aim of this study is to evaluate the ash content and melting temperatures of the multi-crop biomass pellets. The pellet biomass feedstock was grown under the leadership of prof. K. Romaneckas and PhD student J. Balandaite in a multi-crop experiment at the Experimental Station of Vytautas Magnus University Agriculture Academy for the period 2020–2022. Three crops (hemp, field bean and maize) were grown in 7 different fields: 3 samples of mono (maize - code S-Mz, fibrous hemp - code S-FH, field bean - code S-FB) 3 samples of binary (maize and fibrous hemp - code MIX2-1, maize and field bean - code MIX2-2, fibrous hemp and field bean - code MIX2-3) and one sample of ternary (maize, fibrous hemp and field bean - code MIX3-1) crops. From the raw materials which were grown in fields, 7 different types of pellets were produced each year and their ash content and ash fusibility determined. The amount of ash was determined according to the standard LST EN ISO 18122:2016. Ash melting points are determined according to the standard ISO 21404:2022. The lowest determined ash content (4.49%) was after burning the pellets made from MIX2-1 biomass grown in 2020 in the same field. The highest ash content (8.87%) was found in the S-FH pellets (biomass grown in 2022). The ash content of all pellets did not exceed the maximum permissible values of ash content set in the standard ISO 17225-6:2021, which defines the requirements for non-woody biofuel pellets. This standard does not define limit values for ash melting temperatures, it only requires that they should be specified. The ash deformation temperature limit specified in the ENplus handbook is ≥ 1100 °C for ENplus A2 and ENplus B pellets, as well as ≥ 1200 °C for the better quality ENplus A1 pellets. In this case, the limit value of the melting temperature of wood pellets is defined, which can serve to evaluate the quality of multi-crop biomass pellets. When evaluating the results of determined ash melting temperatures at the point DT (°C), it was found that the highest ash deformation temperature was for S-FH biomass pellets, which varied from 1322 °C (biomass grown in 2020) to 1461 °C (biomass grown in 2021) and S-FB biomass pellets (1141 °C in 2020 and 2022 and > 1550 °C in 2021). High ash deformation temperature was also determined for pellets made from MIX2-3 biomass grown in 2021 and 2022 (1463 °C and 1216 °C respectively), as well as for pellets made from MIX2-1 biomass grown in 2021 and 2022 (1296 °C and 1179 °C respectively). Pellets made from the biomass of the ternary crop (MIX3-1) grown in 2021 also had a sufficiently high ash deformation temperature - 1148 °C. Meanwhile, S-Mz pellets had the lowest ash deformation temperature, ranging from 976 °C (2020 biomass) to 1004 °C (2021 biomass). Due to the lower melting temperature when burning S-Mz pellets, attention must be paid to the burning type and it is also necessary to consider using this biomass in mixtures with hemp or other raw material, whose ash melting point is higher. The analysis of ash content and ash melting temperatures shows that multi-crop plants can be a promising raw material for the production of solid biofuel pellets.

Keywords: multi-crop biomass, solid biofulel, pellets, ash melting temperatures.

EFFECT OF MINERAL ADDITIVES ON THE MELTING BEHAVIOUR OF WHEAT STRAW AND FIBRE HEMP ASH

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ABSTRACT

The influence of seven mineral additives on wheat straw (*Palaeas triticum*) and fibre hemp (*Cannabis sativa*) ash melting behaviour was investigated. The aim was to characterise ash melting with the mineral additives magnesium oxide (MgO), silicon oxide (quartz) (SiO_2), kaolin ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$), calcium oxide (CaO), and two types of phosphogypsum (hemihydrate ($CaSO_4 \cdot 0{,}5H_2O$) and dihydrate ($CaSO_4 \cdot 0{,}5H_2O$)) and to compare the quality of the results obtained with those using potassium carbonate (K_2CO_3) as the ash melting modifier. All these additives were added to raw biomass samples at dosages of 1 %, 2 % and 4 %. The main elements in fibre hemp biomass were Ca, Si, P and K, Si, P in wheat straw. The primary components of hemp fibre ash at a temperature of 550 °C were $CaCO_3$, $Ca4O(PO_4)_2$, and SiO_2, and those in wheat straw ash were KCl, K_2SO_4, $KCaPO_4$, K_2CO_3 and SiO_2. XRD analysis revealed that the effect of combustion temperature on the crystalline phases of the biomass ash was significant. Based on the data obtained, MgO was most suitable for use as an additive for both wheat straw and hemp biomass due to the highest ash melting temperatures. Even when only 1 % of MgO was used, all melting temperatures (SST, DT, HT, FT) were significantly raised while having no concequential effect on the change in ash content. Also, a positive but less significant change in the melting temperatures of wheat straw ash was observed using $Al_2O_3 \cdot 2SiO_2 \cdot 2H2O$, CaO, and phosphogypsum additives at a concentration of more than 2 % mass ratio of raw material, however, the ash content was highly increased.

Keywords: biomass, additive, ash melting, wheat straw, fibre hemp

NATURAL RESOURCES: *ARTEMISIA DUBIA* WALL

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ABSTRACT

By encouraging the increase of biological diversity, the cultivation of agricultural crops is aimed at attracting non-food plants as well and increase their abilities to be grown in different environmental conditions. Such crops could be used as natural resources for new bioproducts (bioplastics, biochar, biofuel, biopesticides). The aim of the study is to analyse the productivity *Artemisia dubia* Wall and biomass utilization possibilities.

Plants of the *Artemisia* genus are more common in the regions of East Asia and Europe. 11 species of *Artemisia* plants are found in Lithuania. One of the least studied and known is the *Artemisia dubia* Wall. A Field experiment of *Artemisia dubia* growth was set up in central Lithuania. To see the differences of biomass in different soils, the obtained results are compared with the same experiment set up in the western (acid soils) and eastern (sandy soils) regions of Lithuania. Two growing densities (5000 and 20000 crops per hectare) were combined with different fertilization treatments (N 0, 90 and 180 kg ha^{-1}) and cuts per vegetation season (1, 2 and 3 cuts). Crops were tested for biomass productivity and taken plants samples for further chemical analysis (active compounds, carbon, nitrogen, etc.).

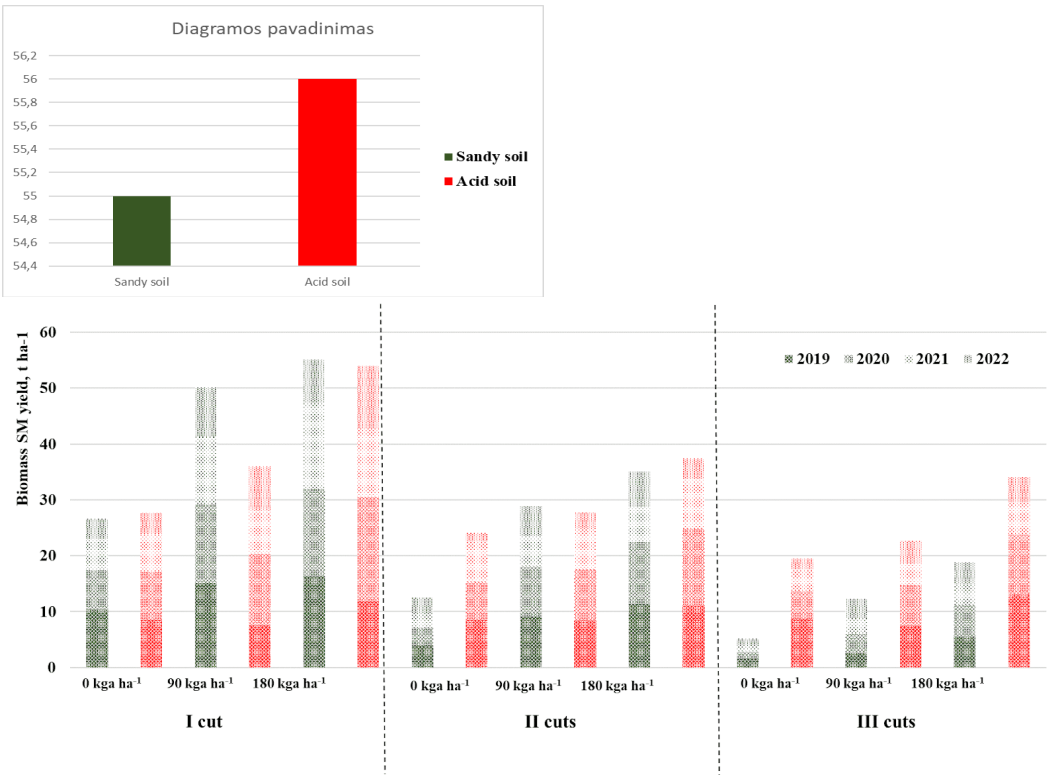

Figure 1. *Artemisia dubia* Wall biomass SM yield 2019-2022 in different soil.

Artemisia dubia is non-food crop, characterized by high productivity not only in neutral, but also in acidic soil. Therefore, abandoned, or unproductive lands could be planted with *Artemisiai dubia* Wall. Once planted, *Artemisia* plants can be harvested year after year. Perennial plants can produce up to 28 t ha^{-1} biomass in northern climate conditions. High biomass productivity is influenced by the height of the plants, which can reach up to 2.5 m after fertilization with additional nitrogen fertilizers. Unlike the ordinary hardy, plants of this type of form flowers, but due to the short growing season, they do not have time to mature seeds. *Artemisia dubia* Wall is rich in secondary metabolites and has highly

antimicrobial, insecticidal, phytochemical and antioxidant properties. The high biomass productivity of *Artemisia dubia* Wall provides an opportunity to develop new bioproducts.

Keywords: Artemisia *dubia* Wall, biomass yield, bioproduct

OPTIMIZATION OF CAROTENOID ACCUMULATION IN RHODOTOROLA YEASTS

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ABSTRACT

Carotenoids are bioactive molecules widely researched for application in phytomedical, chemical, pharmaceutical, food, and other industries. Yeasts from *Rhodotorula* genera are considered major microbial producers of carotenoids. These colored oleaginous yeasts possess diverse carotenoid profiles and amounts. In this work, *Rhodotorula* yeast species were isolated from the natural environment and differentiated using morphological and molecular methods. Based on the restriction fragment length polymorphism analysis and sequencing of the ribosomal DNA internal transcribed spacer region (ITS), *R. diobovata, R. mucilaginosa,* and *R. glutinis* species were identified. For the analysis of carotenoid production, yeast strains were grown on solid media at different temperatures ranging from 20 ºC to 37 ºC. It was observed temperature-dependent yeast growth. For R. *diobovata* and *R. glutinis* the highest amount of biomass was collected when yeasts were cultivated at 25ºC temperature. For *R. mucilaginosa* the optimal temperatures for culture growth were 25°C and 30°C. The yeast strains were grown at different temperatures and biomass was collected and applied for the extraction of carotenoids. The absorption spectrum of yeast extracts was measured at wavelengths ranging from 380 to 530 nm. The highest concentration of total carotenoids was determined for *R. glutinis* and *R. mucilaginosa* cultured at 20°C and for *R. diobovata* - grown at 25ºC temperature. When yeast cells were grown at 30°C, the accumulation of carotenoids in all tested yeast strains was low. The obtained data suggests that isolated *Rhodotorula* yeasts can be promising for carotenoid production.

Keywords: Yeast, Rhodotorula, carotenoids production, temperature.

CONFERENCE PAPERS

2. PHYSICAL SCIENCES

2.1. Thermal Physics, Fluid Mechanics and Metrology

EFFECTIVENESS OF HEAT TRANSFER BY SOUND AND THERMAL CONDUCTIVITY IN SUPERFLUID

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ABSTRACT

A unique feature of such unusual substances as superfluid liquids, superconductors, extremely pure crystals and nanostructures under certain conditions, is the ability to transfer heat almost without resistance. This feature is due either to the purely quantum nature of these substances or to the ideality of their crystal lattice. In these cases, there is a mechanism of heat transfer in the sound wave, the so-called second sound, which is a fluctuation in the density of thermal excitations. Therefore, the formal coefficient of thermal conductivity of such substances is almost equal to infinity, and it is impossible to create an equilibrium temperature gradient in them. Thus, these substances are ideal conductors of heat. The use of such substances to pump heat from heating elements of computing devices or elements for energy conversion could solve the problem of heat balance in these devices.

In this report, the problem of the efficiency of heat removal in a superfluid liquid due to the second sound in comparison with the thermal mode of heat conduction is considered. The model problem of heat removal from an oscillating heating source in a superfluid liquid is solved. A comparison with experimental observations is made and the possible application of the studied mechanisms as cooling power for computing devices is considered.

Keywords: Superfluid, second sound, thermal conductivity, heat transfer, heat flow

A COMPUTATIONAL STUDY OF MULTI-REGIME MIXING IN TRIPLE FLOWS

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ABSTRACT

The mixing of fluids is pivotal across numerous applications, ranging from drug delivery in medical contexts to species mixing in chemical processes and heat transfer or fuels injection in nuclear reactors. Although most literature suggests that peak mixing efficiency occurs in turbulent regimes, recent experiments of triple flows with constant Reynolds ratios conducted by Thermal Hydraulics Verification and Validation Laboratory at Texas A&M University in a matched index of refraction tunnel challenge this notion. It was revealed that when mixing flows exhibit distinct regimes, mixing efficiency is advanced, and, moreover, huge pressure drops are avoided. Yet, the experimental scope faces limitations in exploring various flow conditions' combinations and capturing 3D instantaneous flow fields.

To complement these experimental endeavours and, eventually, study the suitability of turbulence models for varying mixing regimes, we conducted a CFD study of the phenomena. Using OpenFOAM-11, we carried out simulations of the triple flows observed in the Thermal Hydraulics Verification and Validation Laboratory experiments. Validation using mean flow fields, as well as profiles of covariance of velocity oscillation components indicate that obtained results match the experiments well, thus providing justification for calculations using a denser range of inlet velocities that were not originally tried in the experiments.

Analysis of results obtained in a diverse set of inlet velocities revealed mixing efficiency dependence in higher resolution, and successfully identified critical points, where mixing efficiency experiences abrupt shifts. These findings not only complement experimental data but also pave the way for evaluation of turbulence model suitability for multi-regime mixing. Finally, the study serves as a starting point for flow topology investigation and performing similar mixing simulations with varying Reynolds ratios.

Keywords: Multi-regime mixing, Triple flow, Computational fluid dynamics, OpenFOAM, Turbulence

NUMERICAL ASSESSMENT OF FLUID FLOW CHARACTERISTICS IN MICRO PIN-FIN CONFIGURATIONS

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ABSTRACT

Thermal management is a major challenge in achieving high performance in electronic devices. Micro fin channels have been developed to address this issue, because of their high surface area per unit volume, which enables effective heat transfer and uniform temperature distribution. The fluid movement around these fins enhances mixing, thereby improving heat dissipation. These cooling solutions are mainly designed for high-power semiconductors like processing chips and LEDs, yet their compact and efficient design is suitable for a wide variety of applications.

Computational fluid dynamics simulations were performed to investigate how changes in pin-fin diameter and channel height affect the flow dynamics and hydrodynamic properties of the micro pin-fin array. These simulations were carried out using the OpenFOAM software, employing at least second-order spatial discretization methods. The models were validated across a spectrum of grid resolutions with varied computational domain to ensure the results are not dependent on the grid size and domain. Analyses were performed on several pin-fin designs with different diameters in an inline configuration. Additionally, simulations were run at various Reynolds numbers to study the flow patterns across different fluid regimes and evaluate pressure drop.

This paper analyses the flow patterns and associated pressure losses in a micro-pin array over a wide range of Reynolds numbers and various geometric configurations. The study found that reverse flow occurs at the end of the pin-fins, resulting in the formation of wake regions characterized by elongated vortex structures. As the Reynolds number increases, the vortex pairs between the pin rows become unstable.

In fully developed flow, whether laminar or turbulent, a smaller pin-fin diameter is associated with a smaller pressure drop. However, under unstable flow conditions (specifically with a H200:D80), the pressure drop reaches its peak due to the presence of three-dimensional vorticity. Furthermore, it is noteworthy that larger pin diameters introduce more perturbations to the flow structure, making the flow behaviour less stable. By using smaller diameter pins, it is possible to achieve higher velocity while maintaining the same Reynolds number. This results in turbulence that is characterized by a narrower wake region.

Keywords: micro pin-fin, flow characteristics, computational fluid dynamics (CFD)

2.2. Material Sciences and Technologies

AN ECO-FRIENDLY AND FREE APPROACH TO WATER REMEDIATION WITH BIOSORBENTS

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ABSTRACT

Water contamination poses a critical challenge in identifying effective water treatment solutions. Biosorbents as natural or modified biomaterials, have emerged as remarkable candidates, because of their cost-free and environmentally friendly characteristics offering promising results for addressing this issue. This abstract provides an extensive overview of biosorbent waste, in this case chamomille tea residues as possible materials in water remediation.

To substantiate the efficacy of this material in water purification, the ICP-OES (Inductively Coupled Plasma-Optical Emission Spectrometry) technique and AAS (Atomic Absorption Spectroscopy) was employed to quantitatively measure the concentrations of metals, specifically lead (Pb) and cadmium (Cd). The concentration of the metals before and after treatment with chamomile residues was measured. Additionally, to elucidate the morphological characteristics of the biosorbents' structure, analytical methods such as FTIR (Fourier Transform Infrared Spectroscopy) and SEM (Scanning Electron Microscopy) were utilized.

The results yielded exceptional outcomes, showcasing the remarkable efficacy of chamomile tea residues in water remediation. In specific cases, these residues demonstrated an impressive purification rate of more than 95%, underscoring their effectiveness in removing metals from aqueous solution. Notably, biosorbents exhibit several advantages over traditional water treatment techniques, including cost-effectiveness, high selectivity, and biodegradability.

Keywords: water contamination, biosorbents, remediation, new approaches

EFFECT OF CHROME-NICKEL DOPING ON THE STRUCTURE AND PROPERTIES OF DIAMOND-LIKE CARBON FILMS

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ABSTRACT

The diamond-like carbon (DLC) films production process has undergone extensive approaches to improve their properties and functions, so it can meet the needs of several applications in broad fields such as biological implants, automotive industry, micro/nano-electromechanical systems (MEMS/NEMS), magnetic storage devices, solid-state batteries and more. Thus, various metal dopants such as Ag, Ti, Ni, Cr, Ag, Mo, etc. are used to deposit metal doped diamond-like carbon films. The usage of two metals doping of chrome and nickel was reported in several literature research. The chromium incorporated DLC films demonstrated superior mechanical and tribological properties, and reduced internal stress value, likewise the addition of nickel into DLC films allows to reduce residual stress, increase wear resistance of the DLC films. In this research both metals were used simultaneously as co-dopants in the DLC films.

The Chrome-Nickel doped amorphous diamond-like carbon thin films (Cr/Ni-DLC) were deposited on Si (100) substrates by magnetron sputtering. The graphite and the Cr-Ni cathode currents were fixed at 1.5 A and 0.25 A, respectively. The Cr-Ni target consists of 80% Ni and 20% Cr. The deposition duration was 10 min. The Cr and the Ni contents in the coatings were regulated by adjusting a slit wide in a shield mounted above the Cr-Ni target. It was obtained that the concentration of Cr and Ni in DLC films varies from ~2 to ~5 at.% and from ~4.5 to ~22 at.% for Cr and Ni, respectively. The increase of the Cr-Ni content led to a slight increase in the oxygen amount up to 19 at.% in DLC films. The Raman spectroscopy revealed that the sp3 C-C bond fraction decreased with increase of the Cr-Ni content due to the metal catalyst effect as obtained, which effectively promoted the graphitization and slight oxidation. The microhardness measurement indicated that the addition of low amount of Cr-Ni slightly reduced the hardness of DLC films. The atomic force microscopy (AFM) was used to reveal the surface morphology and nano-tribological properties. The AFM results demonstrated that the surface roughness was reduced with the addition of low amount of Cr-Ni. The lowest friction coefficient was obtained when the Cr-Ni content in doped DLC film was about 2.0 and 4.5 at.%. Further increasing of Cr-Ni doping content led to high friction coefficient.

Keywords: Cr/Ni-doped diamond-like carbon, microstructure, friction coefficient, nano-hardness.

EXPLORING SEAWEED-DERIVED BIOCHAR AS A SUSTAINABLE CATALYST SUPPORT: PYROLYTIC FABRICATION AND CHARACTERIZATION OF IRON AND COPPER SUPPORTED CATALYSTS FROM BALTIC SEA MACROALGAE

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ABSTRACT

Over the preceding two decades, there has been a discernible escalation in nutrient concentrations within marine coastal environments, leading to an augmentation in primary productivity. This heightened productivity manifests in either extensive phytoplankton blooms or the proliferation of opportunistic macroalgae. The stranding of seaweeds can induce hypoxia, instigate the release of hydrogen sulfide into the aquatic environment, cause animal mortalities, and bring about a decline in marine and estuarine biodiversity. Seaweeds, already harvested for food and hydrocolloid purposes, present a potential feedstock for the generation of biochar, characterized as a carbonaceous substrate akin to "biological charcoal." The attainable biochar exhibits a specific surface area ranging from 1.15 to 1227 m^2/g, as determined through the BET methodology, comparable to numerous conventional catalysts. Within this investigation, the authors endeavour to offer a technique for fabricating iron and copper supported catalysts derived from seaweed indigenous to the Baltic Sea, processed via pyrolysis. The catalysts were prepared by impregnating seaweed which were dried, soaked in HNO_3 and KOH solutions and washed before being impregnated with 0,5 mol/l solutions of $CuCl_2 \cdot 2H_2O$ and $FeCl_3 \cdot 6H_2O$ salts. The catalysts undergo characterization via temperature-programmed desorption (TPD), temperature-programmed reduction (TPR), as well as H_2 and CO chemisorption analyses.

Keywords: supported metal catalyst, biochar, chemisorption, sustainable catalysts, seaweed.

HYDROGEN UPTAKE OF ZIRCONIUM ALLOYS IN DEFECTIVE FUEL RODS: EXPERIMENT AND NUMERICAL MODEL

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ABSTRACT

Hydrogen uptake in defective fuel rods by Zr cladding plays an important role in both cladding embrittlement and internal gas pressure build up. The primary coolant may enter the defective fuel rods after the formation of defect. Steam can be formed and hydrogen can be produced inside of the fuel rod as from water by different mechanisms (radiolysis, corrosion). The hydrogen will be accumulated in the gas volume of fuel rod and a part of the available hydrogen will be absorbed by the zirconium cladding tube. The high local hydrogen content in some parts of the cladding can create hydride clusters and at those positions the cladding becomes very brittle. The change of pressure in the primary coolant and/or in the fuel rod will result in stresses that can lead to secondary failure of the fuel rod.

The understanding and detailed numerical modelling of the above listed phenomena need experimental data, which are representative for the physical parameters of the nuclear power plants. There are a large number of tests available on hydrogen uptake of Zr, but most of them were carried out at high temperatures. In the defective fuel rods, during normal operational conditions the typical cladding temperatures are in the range of 300-400 °C.

The computer codes need models based on representative experimental data in order to predict correctly the behaviour of defective rods under different conditions.

Isothermal H uptake tests at 300 °C, 330 °C, 370 °C and 400 °C were carried out with Zircaloy-4 and E110 cladding samples. Hydrogen uptake increased with the increase of temperature and significant differences were found between the two alloys. The experimental data on Zircaloy-4 have already been used for the simulation of defective fuel rods in the framework of the EU R2CA project. New correlation was created for E110 cladding in the above mentioned temperature range, which reproduced well the measured data and which can be introduced into fuel behaviour computer codes.

Keywords: defective fuel rods, hydrogen uptake, Zircaloy-4, E110 alloy, numerical model

INVESTIGATION OF STRUCTURAL, OPTICAL, AND ELECTRICAL PROPERTIES OF TIN SULPHIDE THIN FILMS FOR THE ENERGY STORAGE APPLICATION

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ABSTRACT

Climate change and environmental degradation are a very important threat to Europe and the world. In addition, it includes zero-pollution ambition, restoring ecosystems, environmentally friendly food system, sustainable and smart mobility, clean energy, and etc. To overcome these challenges, the European Green Deal will transform the EU into a modern, resource-efficient and competitive economy, which would ensure few aspects, such as zero greenhouse gas emissions by 2050, economic growth decoupled from resource use and leaving no people and no place behind [1].

Advances in science and technology are fundamentally changing the demands of modern society and modern life. Significant changes in the structure of human life have mainly been attributed to the discovery and production of materials. In general, materials are achievements of civilization. Technologies that use novel materials should make human life safer and more feasible. The rapid growth of human population along with the electricity consumption and the continuous decrease of traditional energy sources (oil, gas, etc.) have forced scientists to study and to develop alternative energy systems [2]. To address the development of alternative energy systems, it is necessary to use more renewable energy sources [3]. The most appropriate and effective method for renewable energy storage and conversion is the use of energy storage devices based on electrochemical technologies, such as the supercapacitor (SC). SCs are one of the most promising energy storage devices because of their high-power density and a long-life cycle compared to batteries and a better energy density compared to traditional capacitors.

The use of non-toxic, earth-abundant materials produced using simple and cost-effective methods is a major challenge for scientists. Tin sulphide consists of earth-abundant elements, furthermore, tin and sulphur, are abundant and non-toxic and the compound has a near optimum direct energy band gap (1.35 eV). In general, thin films of tin sulphide can be synthesized using various physical and chemical deposition routes. However, the structure and structure-dependent properties, as well as the purity of the prepared films, have been found to depend on the deposition method applied [2]. This paper investigates the formation of thin films of tin sulphide on FTO glass substrates using the SILAR method. This synthesis route is beneficial due to the application of earth-abundant, nontoxic materials, using aqueous solutions. In addition, it is a low temperature synthesis route suitable for deposition on large-area substrates.

This paper is based on the production of tin sulphide films using the SILAR method. The films were formed by the absorption of cations on the glass substrate, followed by reaction with anions, finishing with immersion in distilled water in order to remove loosely bounded ions. Then annealing was applied in an inert atmosphere at 300 °C. The physical and chemical properties of the annealed films were compared with those of the non-annealed films. From the data obtained, it is clear that annealing has a strong impact in all areas - well adhered film formation, enhanced compactness, but decreased thickness of the films and clearly expressed XRD peaks. Thermal treatment increases the specific capacitance by up to 6 times. These conditions allowed the obtainment of mechanically stable and electrochemically active tin sulphide films that could be used in supercapacitors.

Keywords: tin sulphide, supercapacitor, green synthesis, nanoparticles

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[2] https://doi.org/10.1002/pssc.201510098
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NOVEL $V_{1-x}Re_xO_2$ FILMS FOR SMART WINDOWS TECHNOLOGY

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ABSTRACT

Vanadium dioxide (VO_2) is a well-known thermochromic material whose optical properties can reversibly change in response to temperature variations. In this respect, thermochromic smart windows, which typically contain a vanadium dioxide film, are of particular interest because VO_2 can respond to changes in ambient temperature and undergoes a reversible semiconductor-metal phase transition at a critical temperature of 68◌˚C. However, there are several challenges that prevent the practical application of VO_2-based materials in smart windows. In particular, the VO_2 transition temperature should be decreased to a value close to room temperature, while the light transmission and solar energy modulation ability should be sufficiently high. To solve the problems of decreasing transition temperature, doping of VO_2 with elements such as W, Mo, Ti and Ni is widely used. However, vanadium substitution dopants in VO_2 differently affects the temperatures of structural transitions and optical properties depending on the valence of the doping element. The doping of VO_2 with rhenium is of particular interest because Re can adopt valence states between +4 and +7 in the octahedral oxygen surrounding. In other words, it provides electron injection and deformation of the crystal lattice and thus plays an important role in decreasing the VO_2 phase transition temperature. However, so far only a few works are known devoted to the synthesis of $V_{1-x}Re_xO_2$ crystals, and to the best of our knowledge no works on thermochromic $V_{1-x}Re_xO_2$ films.

Herein, we report synthesis, characterization, and influence of Re-doping on phase transition temperature of VO_2 thin films deposited on quartz substrates by magnetron sputtering technique and following annealing at ambient atmosphere. The structural and elemental composition of $V_{1-x}Re_xO_2$ ($0.01 \leq x \leq 0.50$) films were characterized by XRD, XPS. The temperature dependence of the transmittance/reflectance optical spectra were provided by transparency measurement and ellipsometry. It was found, the phase transition temperature gradually decreases with increase Re content, reaching 28 ˚C at 8 at.% of rhenium. Re-doped VO_2 composite film that was prepared with Re 1-8 at.% showed good NIR switching efficiency (about 25 %). At higher rhenium contents the optical transmittance of the film decreases significantly.

Keywords: vanadium dioxide, rhenium, phase transition temperature, optical properties, thermochromic smart windows

Acknowledgements

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XRD STUDY OF COPPER SULPHIDE FILMS ON FTO GLASS

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ABSTRACT

Rapidly increasing energy demand is a pressing issue because energy scarcity and environmental pollution are increasing globally. For these reasons, ways are being researched to produce energy that is durable, cheap, and sustainable. In the search for alternatives to fossil fuels, copper sulphides have attracted interest because of their suitable optical, electrical, and thermoelectric properties. Copper sulphides are non-toxic and have a high energy capacity, making them suitable for use in lithium-ion rechargeable batteries and solar cells. The aim of this work was to synthesize copper sulphide films on FTO glass by sequential ion adsorption and reaction (SILAR) method and characterize the films using XRD analysis.

Three compositions of cationic and anionic precursors were used to obtain copper sulphide films: 0.2 M $CuSO_4$ solution with 0.2 M hydroquinone as reducing agent and 0.2 M Na_2S solution; 0.2 M $CuSO_4$ solution with 0.2 M hydroquinone and 0.1 M Na_2S solution; 0.2 M $CuSO_4$ solution with 0.1 M hydroquinone and 0.2 M Na_2S solution. For the deposition of copper sulphide, each sample was prepared in the following steps: firstly, the cleaned FTO substrate was immersed into a cationic precursor for 30s and the copper ions on the top of the substrate were adsorbed, secondly, a sample was immersed in an anionic precursor for 30s. During this step sulphide ions react with copper ions adsorbed on the top and form copper sulphide films. In order to remove loosely bound ions, the samples were washed in distilled water for 10s after immersions in the cationic and anionic precursors. In this study 20 SILAR cycles were carried out. Then, the samples were annealed at 100-400 °C to increase the crystallinity of obtained films.

X-ray diffraction analysis of the copper sulphide films on the FTO glass slides was carried out using a Bruker AXS D8 Advance X-ray diffractometer. The X-ray diffractograms of the films were analysed using the *Search Match* software package. The results show that the phase composition of copper sulphides prepared using 0.2 M $CuSO_4$ solution with 0.2 M hydroquinone and 0.2 M Na_2S solution is similar in annealed and as-deposited samples. The X-ray diffractograms show peaks of the following phases: anilite, djurleite, digenite and chalcocite. Increasing the annealing temperature improves the crystallinity of the film and intensifies the peaks of the phases. The diffractograms of the samples annealed at 100 and 200 °C show very intense peaks of anilite phase at 2θ = 46.249° and of djurleite phase at 2θ = 37.77°. The diffractograms of the samples annealed at 300 and 400 °C also show an intense peak of djurleite phase at 2θ = 37.77° and an intense peak of anilite phase at 2θ = 26.545°. The results of the samples prepared using 0.2 M $CuSO_4$, 0.2 M hydroquinone and 0.1 M Na_2S solutions show that the composition of copper sulphide films is similar, but the intensities of peaks increase at higher temperatures. Intensive peaks of djurleite phase at 2θ = 37.77 and 21.245°, of anilite at 2θ = 27.798° and of digenite phase at 2θ = 51.404° in the copper sulphides films are observed. In the X-ray diffractograms of the samples prepared using 0.2 M $CuSO_4$, 0.1 M hydroquinone and 0.2 M Na_2S solutions, it can be seen that with increasing annealing temperature higher intensity phase peaks are observed. XRD analysis shows the appearance of a high-intensity peak of chalcocite phase at 2θ = 10.887°, also intense peaks of anilite at 2θ = 26.545 and 46.249° and djurleite at 2θ = 37.77°.

Summarizing the results obtained, it is clearly seen that the phases of anilite, digenite, djurleite and chalcocite predominate in the copper sulphides films, therefore the phase composition of films deposited using different concentrations of precursors differs slightly. As the annealing temperature of the samples increases, the composition of the films changes even more, and djurleite becomes the predominant phase of copper sulphides.

Keywords: Copper sulphides, FTO glass, SILAR method, XRD

EVALUATION OF THE OPTIMIZATION OF ACIDIC DEMINERALIZATION ON CHARACTERIZATION OF CHITOSAN ISOLATED FROM SHRIMP SHELLS

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ABSTRACT

Nowadays, one of the most pressing needs in the aquaculture industry is to transform shrimp biowaste into valuable materials such as chitosan, thereby supporting shrimp waste sustainability and advancing green deal targets and circular economy principles. Central to this research is evaluating the optimization feasibility of acidic demineralization on chitosan extraction and characterization. The optimization experiment was conducted using various concentrations of acidic demineralization at room temperature and 50 ℃ at stabilized deproteinization and deacetylation conditions to investigate the impact of acidic demineralization on the physicochemical and structural characteristics of the resulting chitosan. Chitosan production with a high deacetylation degree (89.7-93.8%) for all samples was confirmed by FT-IR spectroscopy compared to commercial chitosan. The ash content, moisture content, and chitosan yield were (0.24-0.89%), (0.26-5.1%), and (15.1-51.3%), respectively. Furthermore, XRD, SEM, and EDS revealed that commercial chitosan possessed an utterly amorphous structure. In contrast, the isolated chitosan samples exhibited a low crystallinity index (3.57-19.58%) due to the formation of natrite (Na_2CO_3) and thermonatrite ($Na_2CO_3.H_2O$). Crucially, this study discovered that chitosan production can be optimized from white Pacific shrimp shells (*Litopenaeus vannamei*) with a high resemblance to commercial chitosan using the optimal acidic demineralization concentrations of 1-3% of hydrochloric acid at room temperature under stabilized conditions of deproteinization and deacetylation processes.

Keywords: Shrimp shells, Chitosan, Demineralization, Optimization, Characterization

SUSTAINABLE–GREEN SYNTHESIS OF SILVER NANOPARTICLES USING AQUEOUS HYSSOPUS OFFICINALIS AND CALENDULA OFFICINALIS EXTRACTS AND THEIR ANTIOXIDANT AND ANTIBACTERIAL ACTIVITIES

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ABSTRACT

Antibiotics are substances widely used in the world to prevent infection. However, due to the widespread use of antibiotics, they are losing their effectiveness. Therefore, the need for new antimicrobial agents is greater than ever. The main target of this study was an examination of silver nanoparticles (AgNPs) by applying different modifications to it using an aqueous solution of Hyssopus officinalis (Hyssopus) and along with spectrophotometric antibacterial and antioxidant activities. Scanning electron microscopy (SEM), energy-dispersive spectroscopy (EDS), and transmission electron microscopy (TEM) were used to confirm the findings. The results showed that AgNPs synthesized from green extract possess antibacterial activities and antioxidant properties against all Gram-negative and Gram-positive bacteria strains. Exclusively, biological activity was governed by tannins, flavonoids, phenolic compounds, and various phytochemicals present in precursor plants. The efficiency of AgNPs was tested using the Kirby–Bauer disk diffusion method for Gram-positive and Gram-negative bacteria strains; also, antioxidant activity was measured. The comparison was done using the data reported for engineered biosynthetic AgNPs, revealing that cultured AgNPs exhibit a more potent effect. The best-suited TEM image showed the spheroidal shape, and the size depended on plant type. It was observed that Hyssopus has a small size of about 16.8 ± 5.8 nm, and for Calendula, it was 35.7 ± 4.8 nm, quite large. The antimicrobial activity of HyO-AgNPs and CaO-AgNPs were 6.00 to 16.50 mm and 7.00 to 17.90 nm, respectively. The highest value shown by Hyssopus in the range of 14.3 to 43.6 mg CGA g^{-1} DW, while Calendula is the lowest by examining the antioxidant activity. It has been concluded that modified AgNPs with Hyssopus and Calendula as base plants can combat pathogenic bacteria and provide stronger behaviour against antibacterial and antioxidant activities.

Keywords: Green synthesis, Calendula officinalis, Hyssopus officinalis, silver nanoparticles, phytochemical analysis, antibacterial activity, antioxidant activity.

OPTICAL CHARACTERIZATION OF CADMIUM SULFIDE FILMS OBTAINED USING GELATIN STABILIZER ON FTO GLASS

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ABSTRACT

In recent decades the biggest focus of humanity's attention is one of most sought-after renewable energy sources - solar power. A wide range of materials, from silicon to perovskite, are currently being studied for applications in solar cell production. Nevertheless, most of these materials do not achieve the required efficiency and some of them require complex and expensive manufacturing processes. One of the market leaders in solar cells is cadmium telluride, CdTe and cadmium sulphide, CdS. Cadmium sulphide is a semiconductor used as a "buffer" layer in CdTe solar cells. CdS is chemically and thermally stable, has a good band gap and strongly absorbs UV and visible light. The application of this layer on top of CdTe allows to reduce absorption losses, system defects, voltage, etc. The aim of this research is to find safer and simpler methods to synthesize high-quality cadmium sulphide particles for the coating of fluorine-doped tin oxide (FTO).

Cadmium sulphide is synthesised by the sol-gel method using a gelatine solution. The latter is used as a "greener" substance of dispersion medium for small cadmium sulphide particles. When gelatin solution forms a gel and polymerizes, it produces strong and clear films because metals and chalcogen ions rapidly penetrate the polymer. However, gelatin, as an organic compound, decomposes at low temperatures, stopping the samples from undergoing high-temperature annealing that could boost the crystallinity of CdS. The sol-gel synthesis consists of several simple steps. Firg. a 5 % aqueous solution of gelatine is first prepared at 90 °C. Then aqueous solutions of 0.005 M cadmium acetate dihydrate, $Cd(CH_3COOH)_2 \cdot 2H_2O$, and 0.02 M thiourea, $SC(NH_2)_2$, are prepared. For the next step, the solutions of the cadmium and sulphur ion precursors are slowly dripped onto the gelatine. The reaction is carried out at room temperature with constant stirring for 10 minutes. L-cysteine is then added, which acts as a capping agent for the CdS particles. Stirring is then continued for a further 20 minutes. The coating of the layers were coated in two ways (the dimensions of the FTO glass substrates were 20x15x3.2 mm): part of the substrates were kept in a solution at 40 °C (sample 1, S1), on the other substrates the mixture was dripped with a Pasteur pipette and spread evenly on the surface, followed by heating to 40 °C (Sampe 2, S2). At 35-40 °C gelatin forms a gel and polymerizes. As a result, uniform and crystalline layers of a dispersed CdS particles are formed.

The optical characterization was carried out via absorption spectral analysis in the UV-visible, UV-VIS spectral range (200-800 nm) using a *Spectronic® Genesys™ 8* spectrophotometer. In addition, the results obtained were used to calculate the values of the band gap values of the layers obtained using the Tauc diagram method.

The prepared CdS layers absorb the radiation most intensively at 330-340 nm. These values are very close to the wavelengths absorbed by smaller cadmium sulphide particles, 350-400 nm. Larger particles tend to absorb radiation in the 400-600 nm range. This is confirmed by the calculated band gap values, which are also in line with the band gap values for smaller CdS particles around 2.6 eV.

Analysis of the UV-VIS absorption spectra and Tauc diagrams of the CdS samples obtained with the gelatine solution suggests that smaller sizes of cadmium sulphide particles may also have formed during this synthesis. Thus, from the obtained results it can be inferred that to synthesize CdS particles with suitable optical properties, it is not necessary to use dangerous stabilizing agents such as: trioctylphosphine oxide (TOPO), 11-Mercaptoundecanoic acid (MUA), etc.

Keywords: cadmium sulphide, coating, band gap.

STUDY OF CHITOSAN AS A SEED TREATMENT

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ABSTRACT

Chitosan extracted from chitin is soluble in weak acids and forms gels and films [1]. The antifungal activity of chitosan in agriculture is supported by several factors: the molecular activity of chitosan, the type of micromycetes and the interaction of environmental factors with chitosan [2]. These properties encourage the study of chitosan further in the field of seed treatment because micromycetes cause significant crop losses. In this study, chitosan with different molecular weights (high, medium, and low molecular weight) and in different concentrations were tested as a substance that can inhibit the growth of micromycetes on natural, non-sterilised seeds of spring wheat 'Koksa' and spring barley 'Podarek'.

The fungicidal activity of chitosan usually increases with increasing concentration, but there are also cases when a strong fungicidal efficiency is seen when using higher concentration chitosan preparations, which is suppressed and the growth of micromycetes begins [3]. This may be due to the ability of some micromycete enzymes to break chitosan down to glucosamine units and turn it into an energy source. Therefore, three different concentrations of each molecular weight of the chitosan were used: 0.5 $g \cdot l^{-1}$, 1 $g \cdot l^{-1}$, and 2 $g \cdot l^{-1}$, in the study to identify the effect of concentration. Chitosan gels were obtained by dissolving chitosan powder in weak acetic acid (1%). Summer cereal seeds were coated with chitosan gels by dipping the seeds into the prepared gels and pulling them out. After coating seeds were sown on potato agar in Petri dishes. Micromycete colonies were identified and counted five days later. Fungi of *Bipolaris* spp. *Alternaria* spp., *Penicillium* spp., *Ulocladium* spp., *Mycelia sterilia*, *Saccharomyces* spp. and *Mucor* spp. – were detected on the seeds of spring wheat 'Koksa'; whereas *Bipolaris* spp., *Aspergillus* spp., *Alternaria* spp., *Penicillium* spp., *Ulocladium* spp., *Mycelia sterilia*, *Saccharomyces* spp. and *Mucor* spp. Were defined on the seeds of spring barley 'Podarek'.

In conclusion, the effect of low molecular weight chitosan on *Bipolaris* spp. *Alternaria* spp. and *Saccharomyces* spp. was defined. The fungicidal effect of high molecular weight chitosan on *Bipolaris* spp. *Penicillium* spp. and *Mycelia sterilia* micromycetes was also determined. A correlation by concentration was observed: solutions with higher concentrations have a greater negative effect on the amount of all identified micromycete genera.

Further studies are required to determine the interaction between molecular weight and concentration of chitosan and the impact on fungicidal efficacy.

Keywords: Chitosan, fungicides, summer cereals, seed treatment.

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2.3. Combustion and Plasma Processes

CATALYTIC PYROLYSIS OF LIGNIN WASTE FOR HIGHER-ADDED-VALUE ENERGY PRODUCTS RECOVERY

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ABSTRACT

For the past couple of decades, incresed energy demand has resulted in massive fossil fuel consumption that causes a lot of environmental concerns. Therefore, as fossil fuel resources are getting low and their usage causes a lot of environmental damage, the potential and development of bio-based energy have become the solution for all of these problems. There are many ways to obtain biofuels. However, the cheapest and one of the most effective methods have not been recognised and used to its highest potential. The most abundant source of bio-based energy production is lignocellulose (LCB). The main components of LCB are cellulose, hemicellulose and lignin. All these components are located in the plant cell walls, but lignin is incorporated mainly to form wood and provide strength and stability. In many industrialisation processes like papermaking, lignin is separated from other biomass components as a residual material and becomes non - usable waste. Lignin is a very stable polymer and after the chemical separation of cellulose and hemicellulose, it cannot be melted or moulded. Thus, one of the most promising methods of lignin's application is thermal utilization. In order to analyse lignin's thermal properties and chemical structure, catalytic pyrolysis processes were studied. In this study, all experiments with or without catalyst (ZSM-5) were carried out in a micro - scale thermogravimetric analyzer (TGA) Netzsch Jupiter F3 (Germany). The maximum temperature of the decomposition reaches 900°C, while the emitted gaseous products were analyzed using a combined TGA and Fourier transform infrared spectroscopy (FTIR) system. Moreover, further analyses were performed using gas chromatography - mass spectrometry (GC-MS) methods. While analysing thermal decomposition behaviour with the catalyst, the mixture of lignin and catalyst itself was made by the proportions of 1:1. For the comparison, the same analytic experiments were carried out with biomass of wood pallets.

ANALYSIS OF AGGLOMERATION AND FOULING PROCESSES DURING AGRO BIOMASS COMBUSTION IN LOW-TEMPERATURE BED

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ABSTRACT

In conventional fuel-burning equipment, the temperature within the fuel bed may reach a range of 1000–1200°C. Fluidized bed technology, commonly utilized in bubbling fluidized beds, maintains lower bed temperatures, typically around 850°C. Consequently, both types of combustion technologies cannot effectively accommodate the burning of agricultural biomass due to the low biomass ash melting temperature, which can escalate to a range of 700–800°C. A thorough examination of scientific literature indicates noticeable disparities in the chemical composition of agricultural biomass compared to wood or similar biomass types. Agrarian biomass is characterized by elevated levels of potassium (K), sodium (Na), phosphorus (P), and silicon (Si), while calcium (Ca) and manganese (Mg) concentrations are notably lower. Additionally, agricultural biomass exhibits significant concentrations of sulphur (S) and chlorine (Cl). During the combustion of agricultural biomass, the presence of potassium (K), sodium (Na), sulphur (S), and chlorine (Cl) in its composition leads to the formation of diverse chemical compounds. When the process temperature exceeds 700°C, potassium (K) evaporates, transiting into a gaseous state and reacting with chlorine (Cl). This results in the formation of gaseous potassium chlorides (KCl), which subsequently solidify and manifest as fine particles known as aerosols. These aerosols adhere to the boiler's metallic surfaces impeding the heat transfer process. Chlorine (Cl), inherent within the aerosol composition, subsequently undergoes a reaction with the iron (Fe) present in the metal structures of the boiler, leading to the corrosion of these components. Silicon (Si), phosphorus (P), and potassium (K) found in agricultural biomass generate diverse complex compounds, such as silicates, during the combustion process. Throughout experiments involving the combustion of crushed corn cubs and straw pellets, the temperature within the fluidized bed reached 650–750°C. An analysis of the potassium (K), sodium (Na), sulphur (S), and chlorine (Cl) at varying layer temperatures revealed a decrease in their concentrations as the bed temperature decreased. During these experiments, the concentration of carbon monoxide (CO) measured within the range of 600–700 mg/Nm^3 and nitrogen oxides (NO_x) registered between 350–500 mg/Nm^3 at a 3% oxygen (O_2) concentration in dry flue gas. Hence, the agricultural biomass combustion technology and low-temperature bed and its operational parameters prove suitable for facilitating the efficient combustion of agricultural biomass. Moreover, no agglomeration of the fluidized bed was observed throughout extended experiments lasting 8 hours.

Keywords: Agricultural waste, ash agglomeration, heating surface fouling, alkali aerosols

ANALYSING AN ANN MODEL FOR LAMINAR BURNING VELOCITY: STRATEGIES FOR IMPROVEMENT

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ABSTRACT

In recent years, hydrogen has emerged as a promising alternative to environmentally unfriendly fuel. However, the safety implications of hydrogen explosions resulting from leakages necessitate a comprehensive understanding of hydrogen combustion and control of accidents caused by hydrogen reactions. For this reason, methods capable of fast and accurately calculating combustion processes of hydrogen mixtures are needed.

In our previous work we introduced an Artificial Neural Networks (ANN) model to estimate Laminar Burning Velocity (LBV). Our developed ANN proved to give lower mean squared error and mean absolute error against experimental data from literature compared to Malet correlation and other tested machine learning methods. While model gave good agreement with experimental data, some strange behaviours were noticed during the model application.

In this paper thorough analysis of developed model was conducted and shortcomings in predicting LBV at high temperatures and specific pressures were observed. These shortcomings could appear due to various reasons; insufficient amount of data, bad selection of activation functions, low number of neurons, etc.

It was observed that while model gives fairly good predictions in respect to equivalence ratio it tends to give non-physical predictions in respect to pressure. This strange behaviour appears in areas between experimental data points. Since model shows good agreement with data, it is possible that these non-physical predictions appears due to lack of experimental data or low number of neurons.

Another problem observed in our analysis appears in dependence on temperature. Analysis show that for high temperatures (>570 K) predicted LBV stops to increase. Theoretically, increase in temperature should lead to higher LBV values. This shows that model is applicable only up to 570 K temperature. This is mostly the case because only experimental data up to 573 K temperature was used for ANN training.

Following the analysis, we suggest strategies which can be applied to improve our and other machine learning models ensuring that suggested techniques are universal and focused on creation of light neural networks.

Keywords: artificial neural networks, combustion modelling, hydrogen, laminar burning velocity, machine learning

HIGH-HARDNESS ALUMINA COATINGS DEPOSITED USING ATMOSPHERIC PLASMA SPRAYING

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ABSTRACT

Plasma spraying is a thermal spraying method that uses a high-temperature plasma jet to deposit molten or semi-molten particles onto the substrate surface to form a coating with the desired properties. A powder feedstock is injected into a high-temperature plasma jet, which undergoes rapid heating and acceleration. An experimental investigation was performed using a mixture of air and hydrogen gas for plasma generation, and Al_2O_3 dispersed particles 40-160μm in size as a feedstock. Subsequently, sprayed particles impact the surface of the stainless steel substrate, instantaneously splashing, forming a fragmented splat with irregular edges and rapidly solidify forming a high-hardness coating. The inherent complexity of plasma spraying arises from the intricate, non-linear relationships between process parameters, in-flight particle characteristics, and final coating microstructure. Elucidating the properties of plasma and in-flight particles is important for optimizing the coating density and deposition efficiency. The research presents the results of the experimental investigation on the behavior of plasma jet during coatings deposition and microstructure of ceramic coatings while changing the power of the plasma torch. The plasma torch operated within a power range of 28 - 45 kW, generating plasma flow of an average temperature of 3000 - 3700 K and an outflow velocity of 900 - 1200 m/s. The properties of formed coatings were investigated using scanning electron microscopy (SEM) and Vickers hardness tester. After analysis of the results, optimal spraying parameters in order to form dense high-hardness and wear resistance ceramic coatings were established.

Keywords: Ceramic coatings, Al_2O_3, plasma spray, hardness

ANALYSIS OF THE PLASMA-ASSISTED COMBUSTION PROCESS OF THE HYDROCARBON-CONTAINING LEAN MIXTURES WITH VARIOUS CO_2 CONTENT.

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ABSTRACT

The expansion of the world's population inevitably leads to rising levels of the consumption of energy careers and human-made pollution of the environment. Consequently, there is a recent emphasis on reusing materials and converting waste into energy. Plasma technologies hold the potential to transform diverse materials into valuable products. This research examines the influence of the altering CO_2 content in the mixture on the plasma-assisted combustion process of hydrocarbon-containing compositions. The primary method used through the investigation was an analysis of the flame behaviour through observation of C_2 and CH radicals emissions in plasma-enhanced flames. By investigating lean combustion conditions with different excess air ratios and plasma frequencies, the study centres itself on the combustibility of the mixtures containing 80, 75 and 70% of the CO_2 in the methane, respectively. Was tested the influence of the voltage characteristics of the plasma, and the results were obtained for 3.66, 6.65 and 8.32 kV, respectively. Results demonstrate that plasma assistance helps generate higher rates of C_2 and CH radical emissions in flame compared with the regime without plasma assistance. The increase of the applied voltage also shows a positive effect on the amount of radicals in the flame, which could mean that the process of hydrocarbon and carbon dioxide fuel parts cracking reaches higher rates. That probably allows higher numbers of those radicals to occur in the flame zone, creating a more intense chemiluminescence picture. For the mixtures under excess air ratio Φ=0.83, the observed influence shows a higher effect than Φ=0.71. The emissions in flame increase by 0.42-0.62% and by 1.13-1.54% for the mixture containing 75% of CO_2 for C_2 and CH radicals, respectively. Mixtures with smaller CO_2 content showed a similar trend, but the intensification effect was higher, reaching 0.64-0.93% and 1.52-2.06% for the mixture containing 70% of CO_2 for C_2 and CH radicals, respectively. At the same time, the influence of the applied voltage showed that a potential increase in plasma power (due to the increase in the applied voltage) provided higher increase rates for the CH radical even applied to leanest tested conditions (Φ=0.71), which could be used for finding optimal regimes of lean combustion of low-calorific value gases that are containing higher percentage of CO_2 component in their content.

Keywords: Lean combustion, Plasma assistance, CO2, Plasma influence.

MODELING OF PLASMA TRANSFERRED ARC AND FLOW IN COMSOL MULTIPHYSICS

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ABSTRACT

Nowadays, thermal plasmas have an extensive range of industrial applications, including cutting, welding, spraying, waste destruction and surface treatment. Understanding the plasma flow and heat transfer characteristics helps optimize industrial processes, identify the most efficient parameters, and achieve desired outcomes. A modelling study was performed that compared the plasma flow and heat transfer characteristics at different plasma torch powers and carrier gas. A numerical model was developed in Comsol Multiphysics, describing physical processes in the transferred arc plasmas at a stationary mode for the thermophysical calculation of the electric arc between the tungsten cathode and stainless-steel anode. Based on the experimental initial data, a fluid dynamics and heat and mass transfer model was developed, and the distribution of plasma flow temperatures, velocities, intensity of magnetic field and other parameters were obtained. A 2D axial symmetry model was solved for several regimes of the plasma torch (electric current 100 -160 A, carrier gas: argon and air). The results show that the laminar plasma jet length increases with increasing gas flow inlet velocity. The radius of the plasma jet is changing depending on the inlet velocity. The plasma arc temperatures assume the highest meanings in air ambient and reach more than 24000 K in the arc zone, whereas in argon ambient plasma temperatures are lower and reach 13000 K. Along the radial axis, the temperature profiles drop in sharp angles and at the distance of x/r = 3 the temperature reaches only 4000K of the initial values. The obtained results can be successfully applied in the development of new plasma technologies for industrial applications: process optimization and equipment design with valuable insights into the relative advantages and limitations of each configuration, predictive analysis, research, and development.

Keywords: plasma transferred arc, temperature profiles, velocity profiles, Comsol

RESEARCH OF THE IMPACT OF ACTIVE SURFACES ON THE FORMATION OF VAPOR FILM UNDER BOILING CRISIS CONDITION

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ABSTRACT

In the last few decades, great efforts have been made to limit the energy consumption in the fuels and support the design of efficient and clean energy systems. This study is also concerned with reducing fuel consumption worldwide, which is considered to be one of the paramount and real problems that affect the environment (air pollution, climate change, water pollution, thermal pollution) and also commercially would guarantee cheap and low fuel consumption. By implementing such strategies, we can effectively reduce the fuel consumption and save money as well as benefiting the environment. More than two centuries, before 250 years ago, Johnn Gottlab Leidenfrost came up with the discovery and observation of the Leidenfrost phenomena, which happens when a droplet of a liquid (water) falls on a superheated surface, then the film boiling is observed. During the film boiling a maximum heat flux will be noticed (boiling crisis) and the heat transfer will be lowest due to the vapour layer which insulates the droplet from the superheated surface. This review studies the impact of the active surface on the formation of the vapour film under boiling crisis which is simply an enhancement of the Leidenfrost point (LDP) by having the most suitable condition for the vapour film formation, hence, the Leidenfrost effect. The vapour layer formation is affected by the surface coating materials, hence; by applying different coating materials with different physical properties (roughness, wettability, conductivity, density) then efficient Leidenfrost phenomena can be achieved. Many previous studies have been done to study the characteristics and the stability of the vapour film and found that the surface wettability and texture have a significant impact on boiling evaporation heat transfer; hydrophilic surfaces generate a greater vapour film rate. To sum up, this work aims to use some different surface coating materials to reduce friction and avoid heat transfer, then create a stable vapour film. By achieving this purpose, then the result of this project will be widely used to reduce fuel consumption.

Keywords: Boiling crisis, heat flux, vapour film, hydrophobic surface, hydrophilic, friction reduction

CONFERENCE PAPERS

3. ENVIRONMENTAL SCIENCES

3.1. Precision Agriculture, Horticulture and Forestry

POTENTIAL OF EUROPEAN ASH (*FRAXINUS EXCELSIOR* L.) ENDOPHYTES

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ABSTRACT

Every year forests are experiencing outbreaks of not only insects but of phytopathogen infestations too. Climate change is at fault for helping fungi to spread and multiply faster and more efficiently. European ash (*Fraxinus excelsior* L.) is no exception, which for the last 20 years has been affected by pathogenic alien fungi *Hymenoscyphus fraxineus* that no chemical or other antifungal substances are able to suppress effectively. There is also a need to search for environmentally safe and sustainable ways to deal with this pathogen, like using microorganisms that can be extracted from the host plant (endophytes). These microorganisms potentially have plant growth promoting (PGP) or other beneficial traits that could help target plant - European ash - by producing siderophores (for enhanced iron bioavailability), indole-3-acetic acid (IAA), fixing nitrogen, solubilizing potassium, organic and inorganic phosphates, and enhancing these traits by forming. Trees inoculated by these PGP microorganisms could exhibit both morphological and biochemical modifications that lead to tolerance of abiotic stressors (induced systemic tolerance). For this experiment, a total of 10 easily cultivated endophytes were extracted from European ash in spring, four of them were yeasts, 6 rod-shaped bacteria. Multiple qualitative tests were completed to check plant growth promoting traits and results varied: while some endophytes showed promising results, others did not exhibit many anticipated plant growth promoting traits. All things considered, more tests should be done on selected endophytes for their potential to suppress phytopathogen *Hymenoscyphus fraxineus* in vitro in order to conduct field studies and find the cure for ash dieback.

Keywords: endophytes, plant growth promoting traits, *Fraxinus excelsior* L., *Hymenoscyphus fraxineus.*

LIGHTING INFLUENCE ON KALE MICROGREEN ANTIOXIDANT ACTIVITY AND SUGAR CONTENTS

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ABSTRACT

The postharvest quality of fresh leafy vegetables is influenced by cultivation conditions. Light is one of the most important cultivation factors, which can influence plants nutritional value. Propper lighting conditions may enhance nutritional value or prolong shelf-life of leafy vegetables, furthermore it may optimize resource usage. Thus, our research aims to evaluate the response of antioxidant activity and sugar contents of kale microgreens to light intensity changes during growth and post-harvest storage. The experiments were conducted in a controlled environment walk-in chamber. Kale (*Brassica oleracea*) microgreens were grown in a peat substrate, with supplemental light-emitting diodes (LEDs) lighting, when spectral composition consisted of deep red 61 %, blue 20 %, white 15 %, and far red 4 %. Applied treatments of light intensity were 150, 200, and 250 µmol m^{-2} s^{-1} of total PPFD, at 16h photoperiod, and 21±3 °C temperature was maintained. Ten days after germination microgreens were harvested and transposed to +4 °C in dark and light (white LEDs) for postharvest storage. Results showed that significant differences occurred only during post-harvest storage: FRAP and DPPH assays showed significant differences in antioxidant activity responses to light intensity treatments during cultivation. 250 µmol m^{-2} s^{-1} PPFD resulted in the highest antioxidant activity responses compared to other intensities. Moreover, during post-harvest storage remained the highest when microgreens were stored in light during the first and last storage days, while stored in the dark the highest activity was obtained on day three. Total phenolic content also displayed changes during storage: 250 µmol m^{-2} s^{-1} PPFD and light conditions during storage resulted in a significant increase. Regarding sugar contents, a significantly lower amount of fructose and glucose was found in microgreens grown under 150 µmol m^{-2} s^{-1} PPFD, this tendency remained during post-harvest storage in both light and dark storage conditions. While the highest amount of mentioned sugars was determined in kale grown under 250 µmol m^{-2} s^{-1} PPFD and stored in light. This research shows the response of kale antioxidant activity and dynamics of nutritionally valuable metabolites, which may be affected by PPFD level during cultivation, and it determines postharvest production quality.

Keywords: Postharvest; shelf-life; LED light**,** *Brassica oleracea***.**

EFFECT OF SOIL ORGANIC CARBON AND TOTAL NITROGEN ON WATER-STABLE AGGREGATES AFTER FREEZING IN CAMBISOL

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ABSTRACT

Soil structure formation and soil aggregate stability are affected by anthropogenic and natural environmental factors and are of great interest worldwide. The goal of this study was to determine the effect of soil freezing-thawing processes on the formation of water-stable aggregates (WSA) in *Cambisol* (Central Lithuania) in relation to soil organic carbon content (SOC), content of total nitrogen (total N), type of soil texture and soil tillage intensity. Three successive freezing-thawing cycles were implemented in a laboratory at three soil water levels (air-dry soil, soil at field capacity and soil near full saturation) on soil cores taken from 0-10 and 10-20 cm layers of long-term conventional tillage (CT), reduced tillage (RT) and no-tillage (NT) field trials of arable land.

The average content of WSA was 0.4 % higher in sandy loam than in loam. Content of WSA, averaged across soil texture, soil depths and water contents at freezing, in NT was 9.4 % higher than in RT and 14.0 % higher than in CT. The mean WSA values were higher in the 5–10 cm than in the 15–20 cm soil depth. The content of WSA in sandy loam was significantly lower than in loam at two soil water (air-dry and near full saturation) levels, while the WSA at field capacity in sandy loam was higher than in loam. In the soil of sandy loam, at air-dry soil, soil at field capacity and soil near full saturation water content, CT decreased WSA content by 1.24-, 1.14- and 1.30-fold, in the soil of loam by 1.09-, 1.23- and 1.02-fold, respectively, compared to WSA in NT. Content of SOC within 0–20 cm soil layer averaged from 7.8 to 8.6 g kg^{-1} in sandy loam and from 11.1 to 12.5 g kg^{-1} in loam. The content of SOC in the soil of sandy loam was 29.9% lower than in the soil of loam. Content of total N within 0–20 cm soil layer amounted to 0.91 - 1.00 g kg^{-1} in sandy loam and 1.21 - 1.46 g kg^{-1} in loam. Soil total N content in the soil of sandy loam was 29.1% lower than in the soil of loam.

Content of WSA, averaged across soil texture, tillage and soil depths, tended to decrease in the following order: air-dry soil > soil at field capacity > soil near full saturation. These results indicate that aggregates in soils that are close to full saturation upon freezing will be less stable after thawing. The relationship between WSA and SOC can be described by a linear regression models during soil freezing-thawing processes: air-dry soil ($y = 4.71x + 14.25$, $R^2=0.50$), soil at field moisture content ($y = 4.90x + 11.50$, $R^2=0.46$) and soil near full saturation ($y = 5.55x + 4.65$, $R^2=0.58$). The relationship between WSA and total N can be described by a linear regression models during soil freezing-thawing processes: air-dry soil ($y = 31.43x + 25.02$, $R^2=0.42$), soil at field moisture content ($y = 42.98x + 10.90$, $R^2=0.67$) and soil near full saturation ($y = 45.53x + 7.59$, $R^2=0.75$). Water-stable aggregate was directly related to soil organic carbon, total nitrogen and increased when the content of SOC and total N increased.

Keywords: air-dry soil, soil at field capacity, soil near full saturation, tillage, sandy loam, loam

DIFFERENCES IN TETRACYCLINE AND CIPROFLOXACIN PHYTOTOXICITY ON *BRASSICA NAPUS*

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ABSTRACT

Tetracycline (TC) and ciprofloxacin (CIP) have recently received extensive scientific attention because of the significant threats they pose to ecosystems and public health as a result of slow degradation in the environment due to poor metabolism and strong adsorption to manure and soil. The aim of this study was to investigate TC and CIP-induced phytotoxic effects on model plant *Brassica napus* at physiological, biochemical and morphological levels. LI-6400 and Handy PEA were used to assess leaf gas exchange and chlorophyll *a* fluorescence, respectively. Concentrations of carbohydrates, low molecular weight antioxidants (carotenoids and polyphenols), malondialdehyde, and hydrogen peroxide were determined in *B. napus* leaves for biochemical analyses. The photosystem II (PSII) performance was suppressed by TC even at an environmentally relevant dose (1 mg/kg), and it decreased proportionally as TC levels in soil increased (10-500 mg/kg). Meanwhile, CIP-induced phytotoxicity manifested at higher concentrations (10, 50 mg/kg) with enormous photosynthetic performance disruption, acute oxidative damage, the breakdown of antioxidative protection and sugar metabolism, and, ultimately, entirely growth retardation at 250 and 500 mg/kg CIP treatments. Therefore, the results of this study suggest that little anthropogenically affected agro-environments with low TC and CIP concentrations do not pose a significant risk to *B. napus*. Still, intensive application of manure and sludge with high CIP concentrations could be disastrous for such relatively sensitive plant species as *B. napus*.

Keywords: tetracycline, ciprofloxacin, *B. napus*, phytotoxicity, photosynthetic performance, oxidative damage.

Funding: This work was supported by Research Council of Lithuania [project number S-MIP-22-70].

EFFECTS OF HARVEST TIME ON PRODUCTIVITY AND QUALITY PARAMETERS OF *ALLIUM SCHOENOPRASUM* L.

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ABSTRACT

The growing demand for non-traditional plant products encourages research into new plant species and cultivars. *Allium schoenoprasum* L. is one of the most popular edible species of the genus *Allium*. Therefore, it is important to study plant cultivars and determine the time of harvesting to obtain quality products. The study was carried out in the experimental vegetable field of the Institute of Horticulture of the Lithuanian Research Centre for Agriculture and Forestry in 2023. The morphological characteristics, productivity, and biochemical elements of seven different cultivars were observed. Measurements were performed and harvest was done three times: in spring, summer, and autumn. The obtained results showed that differences in the morphological characteristics, productivity, and biochemical elements of *Allium schoenoprasum* L. cultivars were influenced by genetic origin and harvesting time. Cultivar No. 11-31 is distinguished with longer foliage in summer, but cultivar No. 04-29 formed wider foliage in autumn. Cultivar No. 04-32 is distinguished with the biggest number of leaves per plant, which reached 1698 units in autumn. The highest content of ascorbic acid reached 12,0 mg g^{-1} of cultivar No. 04-30 during spring harvesting. The highest amount of total sugar was found in the leaves of the cultivar 'Zornaja Rostan' at 5,91 %. The accumulation of dry matter was more intensive in spring for all cultivars. The highest amount of dry matter was found in the leaves of cultivar No. 04-32 at 18,0 %.

Keywords: *Allium schoenoprasum* L., biochemical elements, cultivars, productivity

SUITABILITY MAPS BASED ON THE GIS-MCDA-AHP APPROACH FOR SELECTING THE MOST PRUDENT FORESTRY UTILIZATION

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ABSTRACT

The strategy for choosing the optimal forest utilization system to be applied to a specific case involves the use of the GIS-MCDA-AHP approach. This approach allows for a careful selection of operations such as felling, logging, transportation, and preparation through the creation of one or more suitability maps.

The aforementioned multicriteria analysis and evaluation procedure utilize identified variables (slope, soil bearing capacity, accident risk, road density, vehicle passage frequency, logging distance, wood volume, deadwood, understory value, average trunk diameter, fertility class, productive vocation, tree habitat, soil arthropods, etc.) to select potential alternatives for forest application in the operational context.

By implementing Multi-Criteria Decision Analysis (MCDA) procedures (Zopounidis and Pardalos 2010), Analytic Hierarchy Process (AHP) (Saaty 1977), and rasterizing and georeferencing each listed criterion in a GIS environment, derivated also to the forest management plans, will yield reclassified rasters based on the suitability class for each forestry utilization scenario. Moreover, an additional informational layer will be overlaid for each considered forest operation condition, calculating the overall applicability adequacy of each forest utilization system for every pixel in the examined territory. This is achieved by summing the suitability value for each criterion, weighted by its relative importance determined through AHP.

This process results in a synthesis suitability map, enabling a quantitative evaluation of the appropriateness of the operations for each pixel in the area of interest. It objectively defines the best forest operation strategy by extracting the mean suitability value using the zonal statistics raster command in GIS software. Ultimately, this method provides foresters with greater precision in digital forest management, allowing them to design forest utilization plans for different areas with careful and objective operation selection criteria.

Keywords: GIS, MCDA, AHP, forestry utilization, forestry conservation, forestry management

ANTIOXIDANT CAPACITY IN DIFFERENT NORWAY SPRUCE HALF-SIB FAMILIES, AFTER SEED TREATMENT WITH ELECTROMAGNETIC FIELD

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ABSTRACT

One of the most urgent problems in forestry arising due to climate change is the increase in biotic and abiotic stressors, which are responsible for tree diseases and the stability of ecosystem functioning. Plants have enzymatic and non-enzymatic defense mechanism against biotic and abiotic stressors. Antioxidant systems is one of the major mechanisms, which play important role of reactive oxygen species (ros) scavenging in plants. In order to evaluate antioxidant capacity in different half-sib families, we chose all ten half-sib families of norway spruce. Seeds of all families were dividen into two groups: control (non-treated) and treated with electromagnetic field 2 min. After treatment, non-treated and treated seeds were sowed in the cassettes and laboratory analysis were did with 2-year-old norway spruce needles. The biochemical analysis was done using spectrophotometric method (synergy ht multi-mode microplate reader). Results showed that seed treatment with emf could increase the antioxidant capacity in norway spruce needles. However, the effect is dependent on the half-sib family. Four half-sib families showed an increase in catalase (cat), ascorbate peroxidase (apx), peroxidase (pox), and glutathione reductase (gr) enzymes. However, two out of the four families exhibited a reduction in the superoxide dismutase (sod) enzyme. Our results emphasized, that seed treatment with electromagnetic field can be used as a tool, in order to increase antioxidants capacity in the needles, which can have an impact on plants defense against biotic and abiotic stressors.

Keywords: antioxidant enzymes, electromagnetic field, forestry, *Picea abies*, plant stress, pre-sowing seed treatment

CHEMICAL CHANGES IN PRECIPITATION UNDER DIFFERENT CONIFEROUS TREE CANOPIES

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ABSTRACT

Tree canopies absorb gases such as CO_2, mainly used for tree growth, and SO_2, NO_2, and O_3, reducing their atmospheric concentration. The protective effect of forests in reducing various substances and their dispersion in the environment is highlighted. It is known that different environmental factors, for example, climatic factors, influence atmospheric deposition. Meanwhile, species-dependant pollutant removal could be expected. Chemical transformations within tree canopies modify the chemical composition of atmospheric precipitation before reaching the forest floor. The importance of in situ measurements, which international organizations have emphasized, supports the aim of this study, which is to determine how coniferous tree canopies influence precipitation chemistry.

This study analysed the data from the forest stands dominated by Scots pine, Norway spruce and their mixture, collected in three ICP Forest level II monitoring plots in Lithuania during 2006–2022. The obtained findings revealed that the canopies of all studied coniferous species reduced precipitation acidity but increased SO_4^{2-}, NO_3^-, Na^+, and K^+ concentrations. The total elemental depositions increased by 20–30% when atmospheric precipitation passed the canopies. The highest total depositions of the studied elements were found in the Norway spruce forest than in the Scots pine foreg. Data analysis of this study found no specific effect of coniferous tree species on precipitation chemistry. However, it was assumed that Norway spruce might significantly impact pollutant removal more than Scots pine.

Keywords: Pollution, Precipitation, Throughfall, Lithuania

GREEN SYNTHESIS, CHARACTERIZATION, AND ANTIMICROBIAL ACTIVITY OF SILVER NANOPARTICLES SYNTHESIZED BY *VIBURNUM OPULUS* PLANT BY-PRODUCTS

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ABSTRACT

In recent years resistance against antimicrobials or antibiotics has become a widespread problem and has caused a significant threat to public health. The metal nanomaterials most commonly synthesized include metals such as iron, manganese, nickel, zinc, silver, copper, and cobalt are selected for antimicrobial activity against pathogenic micro-organisms. Green synthesis provides advancement over chemical and physical methods as it is cost effective, and environment friendly, and there is no need to use high pressure, temperature, and toxic chemicals. It has been reported that plant metabolites such as terpenoids, phenolics, tannins, flavonoids, terpenoids, alkaloids, and polysaccharides contribute to the reduction of Ag ions to AgNPs. The novelty of studies is the secondary use of by-products from the processing of fruit and vegetables. After extraction and use of biologically active compounds, the remaining substance will be used as a raw material to produce organic NPs. Extracts of plant by-products of *Viburnum opulus* are used in the work. They are ideal for reducing, stabilizing, and covering the green synthesis of AgNPs. The aim of this study was to synthesize AgNPs using an aqueous extract of *Viburnum opulus*. The morphology of the synthesized AgNPs was carried out by using SEM/EDS and TEM microscopy. Antioxidant activity analysis was performed for the raw and *Viburnum opulus*/AgNPs extracts by different methods: ABTS, DPPH•, CUPRAC, and FRAP assays. The total polyphenol content (TPC) in the extracts was determined according to the Folin–Ciocalteu method, using gallic acid as the equivalent (GAE). The antimicrobial activity was investigated against Gram-negative and Gram-positive bacteria cultures by the agar diffusion test for the evaluation of antibacterial activity. The raw and *Viburnum opulus*/AgNPs aqua extracts contain hydroxycinnamic acid, flavonoids, and phenolic acid derivates that provide antimicrobial and antioxidant activity. TPC content is 3396,90 mg GAE/100 g and 3016,83 mg GAE/100 g. *Viburnum opulus*/AgNPs particles were spherical, 45 nm in size. *Viburnum opulus*/AgNPs inhibit the viability of gram-positive and gram-negative bacteria strains. It is concluded that AgNPs synthesized in extracts have a broad range of biological applications and can be used as an eco-friendly material without having negative.

Keywords: green synthesis, silver nanoparticles, AgNPs, *Viburnum opulus*

MANAGEMENT OF MINERAL NUTRITION TO CONTROL THE QUALITY AND SAFETY OF POST-HARVEST LEAFY VEGETABLES

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ABSTRACT

Fungi destroy up to 30 % of crop products through disease and spoilage processes, while mycotoxin-producing and opportunistic plant pathogens endanger food safety. Moreover, food loss and waste result in significant economic losses. Leafy vegetables are very perishable products with a short shelf-life. Moreover, the major losses are associated with the spread of pathogens during growth, harvest, and storage. To avoid the use of chemical fungicides, it is necessary to create a strategy that allows to keep the produce healthy and safe for humans, as well as reduce economic losses. The aim of this study is to evaluate the influence of mineral nutrition on nutritional value and resistance to fungi at harvest and storage of leafy vegetables. The experiments will be performed in a controlled environment agriculture system using hydroponics. The influence of nitrogen, calcium, and magnesium concentration in hydroponic solution will be evaluated by addressing leafy vegetable (lettuce, spinach, kale et.) growth parameters, nutritional value, resistance to fungal pathogens (*Alternaria* spp. and *Botrytis* spp.) and preservation of crop produce after the harveg. The research is prepared in line with the European Commission's Green Deal Strategy Farm to Fork, which aims to create healthy, sustainable, and resilient food systems. It is planned to perform a series of chemical analyses to evaluate the contents of sugars, phenolic compounds, mineral nutrients, antioxidant capacity and evaluate the safety of leafy vegetable production at harvest day and after short-term post-harvest storage. The results of the study would allow deepen knowledge of plant physiology and pathology and prepare the guidelines seeking the highest value and safe production of leafy vegetables.

Acknowledgment: This project has received funding from the Research Council of Lithuania (LMTLT), agreement No S-MIP-23-20.

Keywords: *Alternaria* spp., *Botrytis* spp., mineral nutrition, leafy vegetables, shelf-life, hydroponics.

OVERVIEW ON THE CONDITION OF THE LITHUANIAN NORWAY SPRUCE POPULATION - VULNERABILITIES AND GREATEST THREATS

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ABSTRACT

As a consequence of recent Europe-wide climatic variations, there has been a notable shift in forest species dynamics and composition. Many regions, notably central Europe, currently face large-scale decline of one of the most economically and ecologically valuable native conifer species, the Norway spruce (Picea abies (L.) H. Karg.). Lithuania, located in the hemiboreal forest zone, with a naturally mixed coniferous/deciduous broadleaf forest species composition, like the rest of Europe has recently seen a decline in the resilience of single species spruce plantations, largely due to changes in milder winters and higher summer temperatures. Though some studies point to increasing growth rates, mortality rates caused by wind damage, the European bark beetle (Ips typographus) and root/stem rot-initiated structural failure have seen a significant rise.

In this study, we aim to discuss our findings on the current condition of spruce and the main causes of mortality by using National Forest Inventory (NFI) datasets. Lithuanian NFI data, recorded on a 4 km x 4 km grid of systematically arranged permanent plots across the country was used. We selected three five-year re-measurement cycles - 2003-2007, 2008-2012, 2013-2017. For this study, all spruce trees larger than 14 cm in diameter were analyzed, and the disturbance agents for all individual trees were identified.

Results show that the average total mortality of spruce trees during the three NFI cycles was 2.28%. The main causing agent of spruce mortality during this period was wind, with 0.84%. Intra/interspecific competition, diseases, and pests were also important causes of spruce mortality with 0.43%, 0.33%, and 0.32% respectively. Wood decay was identified as a potential risk factor associated with wind damage occurrence for spruce individuals: mortality caused by wind among decayed trees was more than double (1.60%) when compared with the mortality among the undecayed tree cohort (0.76%). The model showed the most significant explanatory variables that alter the probability of spruce mortality caused by wind were soil moisture, tree age, stand stocking level, and the presence of tree decay.

BRASSICA COVER CROPS' EFFECT ON SOIL MICROORGANISM DIVERSITY AND ABUNDANCE: A LITERATURE REVIEW

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ABSTRACT

Soil-borne diseases are an economically important problem for crop growers worldwide. Sustainable agriculture and the replacement of synthetic chemical fungicides with safe, environmentally friendly, and effective alternatives to improve soil health, increase plant quality and yield, and reduce soil-borne diseases is a growing aspiration in agriculture. One of the alternative options for pathogen management is the use of *Brassica* cover crops in crop rotation, given their biofumigant activity. Due to the ability of *Brassicaceae* plants to release bioactive substances - isothiocyanates during the hydrolysis of glucosinolates, these plants have a fungistatic effect. Previous studies have shown the inhibitory effect of these plant substances against plant pathogens like *Fusarium graminearum*, *Alternaria alternata*, *Rhizoctonia solani*, *Gaeumannomyces graminis var. tritici*, *Pythium*, *Bipolaris* spp. and other pathogens. In addition, cover cropping provides multiple benefits for plant productivity, weed control, nutrient availability, and biodiversity enhancement. This literature review provides a summary of recent research on the effects of *Brassica* cover crops on soil microbial diversity and abundance, with a focus on pathogen suppression, by screening the major online scientific database sources and papers published in the period from 2014 to 2024. The review examines basic methods for studying microbial diversity and abundance. It discusses the effects of different cover crops of the *Brassicaceae* family on the population, diversity, and abundance of soil-beneficial and pathogenic microorganisms. In conclusion, despite numerous studies showing the potential of *Brassicaceae* cover crops to suppress pathogens, there is still a lack of information on the effect of these cover crops on the overall microorganism population, especially in the northern European climate zone. New insights in the search for alternative biofumigants for agriculture can accelerate the transition away from synthetic and chemical pesticides to more environmentally friendly practices thereby contributing to microbiota diversification and restoration, disease suppression and improved soil health.

Keywords: *Brassica*, cover crops, soil microorganisms, pathogens, microbial community diversity.

EVALUATING THE EFFECTS OF POLYCYCLIC AROMATIC HYDROCARBONS ON SILVER BIRCH SEEDLING HEALTH: LIPID PEROXIDATION, TOTAL PHENOL CONTENT, AND CHLOROPHYLLS AS BIOMARKERS

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ABSTRACT

Polycyclic aromatic hydrocarbons (PAHs) constitute a diverse class of organic compounds characterized by the fusion of two or more benzene rings in different arrangements. These compounds are pervasive environmental pollutants generated from the incomplete combustion of organic substances like fossil fuels. PAHs can affect trees in various ways, primarily through their toxic properties and impact on tree physiology. The accumulation of PAHs in birch trees can lead to various detrimental effects, including stunted growth, leaf discoloration, reduced reproductive success, and increased susceptibility to environmental stressors. Studying the effects of PAHs on various biochemical parameters in different birch half-sib families therefore provides valuable insights into the biochemical mechanisms underlying birch stress responses and ecosystem dynamics.

The objective of this research was to evaluate how certain PAHs impact the levels of lipid peroxidation (MDA), total phenol content (TPC), and the ratio of chlorophyll a/b in different half-sib families of silver birch (*Betula pendula*). Three distinct silver birch half-sib families (112, 86, and 125), representing genetic variations, were cultivated under hydroponic conditions with one of four specific polycyclic aromatic hydrocarbons (phenanthrene, pyrene, fluoranthene, or naphthalene) at varying concentrations (0, 10, 100, or 200 μg L^{-1}). The experimental duration was 4 weeks, following which samples were collected for subsequent biochemical analyses. All biochemical assessments were conducted using a SpectroStar Nano microplate reader (BMG Labtech, Offenburg, Germany).

MDA, TPC, and chlorophyll a/b ratio serve as biochemical indicators for evaluating plant stress responses. MDA reflects membrane damage and oxidative stress levels, while TPC and chlorophyll a/b ratio are linked to non-enzyme antioxidant defence mechanisms. During this study, it was observed that phenanthrene and fluoranthene decreased MDA levels in all studied half-sib families' seedlings, while pyrene and naphthalene increased them in some tested groups. TPC levels indicated that two out of three half-sib families' seedlings predominantly exhibited increased levels, while one half-sib family seedlings experienced decreased TPC levels. The chlorophyll *a/b* ratio analysis revealed that among 112 half-sib family seedlings, levels increased when exposed to all tested pollutants. Moreover, among 86 half-sib family seedlings, the levels decreased more than they increased, whereas 125 half-sib family seedlings displayed only decreased chlorophyll a/b ratios compared to the control groups.

In general, individual half-sib families display unique responses to different types and concentrations of PAHs, resulting in specific alterations in lipid peroxidation, total phenol content, and levels of photosynthetic pigments. The diverse outcomes observed in biochemical analyses suggest that various families harbor distinct defense mechanisms against stress. These findings will be leveraged in future phytoremediation efforts targeting PAHs, aiding in the identification of optimal tree species and their respective families for the establishment of future forests with improved pollutant-removal capacities.

Keywords: Birch, PAHs, phytoremediation, TPC, MDA, chlorophylls

THE EVALUATION OF ANTIOXIDANT ACTIVITY OF *AMELANCHIER ALNIFOLIA* L. FRUITS

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ABSTRACT

Saskatoon berry *(Amelanchier alnifolia* L.) is a shrub, that is found in forests or thickets. Their fruits are small, black-blue berries, accumulating flavanoids, phenolic compounds and anthocyanins. Due to its composition, it has the potential to act as a highly beneficial antioxidant, anti-inflammatory, antitumor, hypoglycemic, antidiabetic, and antiradical agent. The aim of this study was to optimize the extraction and preservation method and to evaluate the antioxidant activity of their ethanol extractions.

The berries were selected from Rietavas region (55.67282, 22.11187) in 2024 year, July month. Three preservation methods have been tested: freeze-dried, dried in 40 degrees C and frozen in -18 degrees C. The berries were mild. Extraction was carried out in an ultrasonic bath at different temperatures (20-25˚C, 50-55˚C), ethanol concentrations of 30%, 50% and 70% for 10, 30, 40 minutes. The ratio of the materials to ethanol was 1:20.

Antioxidant activity was determined by DPPH (1,1-diphenyl-2-picrylhydrazyl) and ABTS spectrophotometric analysis.

Results showed significant differences in antioxidant activity depending on the extraction method. Furthermore, preservation method also showed to have an impact on antioxidant activity of saskatoon berry ethanol extractions. This research shows the dependency of DPPH and ABTS radical scavenging activity to extraction and preservation methods. By the optimization of extraction conditions the increasement of biologically active compounds may be achieved, which lead to further appliance of the berries extracts in pharmaceutical field.

Keywords: *Amelanchier alnifolia***;** antioxidant activity; DPPH; ABTS.

EFFECTS OF RELAY CROPPING GRAIN LEGUME AND WINTER RYE FOR GRAIN YIELD IN AN ORGANIC FARMING SYSTEM

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ABSTRACT

Relay intercropping technique is intended to provide long soil cover with living cover crop and its maintenance after main crop harvest may protect the soil against erosion, contribute to the control of weeds and diseases, provide the next crop with nitrogen and preventing nitrate leaching. This study evaluate system of relay intercropping grain legumes (*Fabaceae*) and winter rye (*Secale cereale* L.) in organic farming conditions. Field experiment was conducted at Lithuanian Research Centre for Agriculture and Forestry, Institute of Agriculture during 2022 - 2023 year with four replicated involved three different relay intercropping combinations: winter rye and grain legumes (pea, lentils and chickpea). The highest grain yield was observed of winter rye sown conventionally in autumn after grain legume pre-crop. However, comparing the grain yield of sole winter rye to relay intercropped rye and lentils or rye and pea rye yield was significantly ($p<0.001$) higheg. The lowest impact for winter rye grain yield was observed in relay intercropped chickpea compared to other relay cropping combinations. The significantly ($p<0.05$) highest grain legumes yield was observed of pea and lentil grown as sole crop. Grain yield of relay intercropped lentil and chickpea was found significantly ($p<0.05$) lowest compared to relay cropping pea. Generally, crop grown as sole shows the highest yield of all tested grain legumes. However, relay cropping system could achieve advantage by optimise the grain yield for two vegetation periods.

Keywords: Relay intercropping, winter rye, grain legumes, yield.

THE IMPACT COMPOST ON NUTRIENT, THE CHANGE IN SOIL AND THE BEETROOT YIELD

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ABSTRACT

Composting is a sustainable practice that involves the decomposition of organic waste materials to create nutrient–rich soil amendments, full of microorganisms helping to transform nutrients into bioavailable forms. There are several different types of compost, each made from specific types of waste materials and made by different ways of composting.

In our experiment we used green waste compost (GWC) produced from materials such as grass, leaves, hay, turf, chopped branches and other plant-based debris; food industry waste compost (FIWC) made from food scraps and leftovers that would otherwise end up in landfills: peelings, apple graters, coffee grounds, spoiled fruits, used paper towels, paper coffee filters, used tea bags and manure waste compost (MWC) created from animal manure - rich in nitrogen and helps to enhance soil fertility. All three types of compost have unique benefits and applications. Green waste compost is a valuable source of carbon and helps to improve soil structure and water retention. Food waste compost reduces methane emissions from landfills and helps to close the nutrient loop in food systems. Manure waste compost adds essential nutrients to soil and promotes healthy plant growth. By utilising these different types of compost, individuals and communities can reduce waste, improve soil health, and support sustainable agricultural practices.

We completed a beetroot experiment by inserting different types of compost in the soil. Determined the main characteristics of the composts and soil such as N, P, K, pH, humus, pollution. After the experiment we monitored the changes of N, P, K in the soil and compared to control (without any inserted compost). The best beetroot yield appeared in the soil with inserted cattle manure compost 38%, the smallest - 7.8% food waste compog. K_2O levels after the experiment increased by 53% in the soil treated with MWC and 43% with FIWC; P_2O_5 levels 15% increased in the soil treated with GWC; mineral nitrogen decreases in the soil with MWC (35%) and FIWC(38%) was lower than with GWC (8.4%).

Conclusion: the impact of compost on the yield and nutrients can increase in the soil depending on the compost quality. The same type compost might show different results depending on composition.

Keywords: compost, nutrient, beetroot yield, mineral nitrogen, K_2O, P_2O_5

THE INFLUENCE OF ORGANIC FERTILIZERS ON THE ACTIVITY OF SOIL MICROORGANISMS

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ABSTRACT

Microorganisms living in the soil affect soil quality and crop productivity. Microorganisms in the soil perform many important functions: break down organic compounds, fix nitrogen, nitrify, denitrify, dissolve phosphate, help plants get the necessary minerals, and stimulate their growth. Although soil microorganisms can reproduce rapidly, adapt to the environment, and remain viable in adverse conditions, it is important to monitor the abundance, diversity, and activity of microorganisms to maintain soil quality and fertility. Often, to stimulate fertility and supplement the soil with missing elements, various fertilizers are used. However, an excessive amount of fertilizers can negatively affect both the soil itself and the populations of microorganisms. Some of the most convenient methods for monitoring soil-dwelling microorganisms are direct seeding in petri dishes and the Biolog™ Ecoplate technology.

During this research, soil samples of different fertilizations were examined, which were fertilized with chemical fertilizers, compost, peat, manure, and the fifth sample was not fertilized at all. The total number of bacteria, yeasts and molds, actinomycetes, spores, and nitrogen-fixing bacteria were determined in the samples, and the functional diversity, abundance, and substrate consumption of the microorganisms were analyzed using Biolog™ carbon source utilization technology, at the beginning and end of the experiment. In order to find out the effect of fertilization and microorganisms on the growth of peas, peas were sown in soil samples using two different methods - coating the seeds with and without nitrogen-fixing and growth-promoting bacteria of the genus *Rhizobium*.

Fertilizer application has been found to directly affect soil microbial communities. Organic fertilizers of animal and plant origin had a positive effect on the diversity and activity of microorganism communities, while the effect of chemical fertilizers was negative on both plant growth and the activity and abundance of microorganisms.

Keywords: soil, microorganisms, fertilization, quality, peas, fertility.

SOIL AGGREGATION AND CARBON STABILIZATION BY APPLYING BIOCHAR AND COMPOST

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ABSTRACT

Due to intensive agricultural practices, like high use of agrochemicals, and fertilizers which deteriorate soil properties, poor soil aggregation, greenhouse gas emissions, and unsustainable crop yield. Therefore, different kinds of organic materials are widely recommended to manage these dispersive soils like biochar, compost, straw, sludge, manures, and plant residues. But biochar and compost gain more attention among others. Biochar application improves soil aggregation by conversion of active aliphatic hydrocarbons into low aromatic carbon structure which affects the flocculation. Also, the presence of the carboxylic and hydroxyl groups on the biochar structure acts as a binding agent that promotes soil aggregation. These soil aggregates physically protect the SOM from degradation. Biochar is also a dynamic source of carbon storage in soil-plant systems and restricts carbon emission to the environment. The biochar mean resistance time is about 1000 years so it's considered suitable for long-term carbon sequestration. Consequently, compost is widely used as an organic fertilizer to increase the organic carbon and nutrient status of soil. However, the compost cannot hold nutrients and carbon accumulation for the long term due to rapid decomposition. Secondly, due to the high decomposition rate, it increases the GHG emission from the soil system. According to the literature study, we concluded that the combined application of biochar and compost is recommended rather than solely the application of both amendments.

Keywords: soil aggregation, carbon sequestration, organic waste.

DEFENSE MECHANISMS OF *PINUS SYLVESTRIS*: BIOLOGICALLY ACTIVE COMPOUNDS IN NEEDLES FOLLOWING *LYMANTRIA MONACHA* OUTBREAKS AND TREATMENT WITH FORAY 76B

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ABSTRACT

In recent decades, coniferous forests have experienced various biotic and abiotic stressors, the frequency of which has increased with the warming trend in climate. In Lithuania, the nun moth (*Lymantria monacha* L.) is among the main defoliators of Scots pine (*Pinus sylvestris* L.) forests, whose population reaches outbreak level every 7–11 years. Currently, the most effective way to control *L. monacha* outbreaks is aerial spraying with the bioinsecticide Foray 76B, which is made from the soil bacterium *Bacillus thuringiensis* subspecies *kurstaki* Strain ABTS-351 (Btk). Btk is toxic only for targeted moths, and forms spores with Cry or Cyt proteins inside the insect during its growth cycle. Even though numerous impact studies show Btk safety on non-target organisms, there is a gap in knowledge regarding the effect of Btk, as a stressor, on the accumulation of defensive compounds in conifer needles. Therefore, the present study aimed to investigate the impact of *L. monacha* outbreaks and the treatment with Foray 76B on the accumulation of polyphenols (TPC), flavonoids (TFC), photosynthetic pigments (chlorophyll a and b, carotenoids), lipid peroxidation (MDA), and soluble sugars (TSS) in *P. sylvestris* needles. Needle samples were collected from visually healthy (control), damaged/untreated, and damaged/Foray 76B-treated plots in 2020 and 2021 (following year after the outbreaks). The results revealed that in both years, increased TPC after *L. monacha* outbreaks (by 34.1% in 2020 and 26.7% in 2021) was negatively correlated with decreased TFC (by 17.6% in 2020 and 11.1% in 2021). The increased TPC was also related to lower levels of MDA, which concentrations decreased in both 2020 and 2021 (by 10.2% and 23.3%, respectively). The results indicated an increased synthesis of chlorophylls and carotenoids in *L. monacha* damaged plots in the following year after the outbreaks. Furthermore, the stimulating effect of the treatment with biological insecticide Foray 76B was also found on chlorophylls and carotenoids in the following year after the outbreaks. The increase in the synthesis of photosynthetic pigments in the damaged/untreated and damaged/Foray 76B-treated plots in 2021 indicates activated *P. sylvestris* defense system after such biotic stressors, which is essential for faster tree growth and forest recovery.

Keywords: *Bacillus thuringiensis*; chlorophylls; MDA; nun moth; Scots pine; secondary metabolites

THE IMPACT OF WINTER WHEAT CULTIVARS MIXTURES ON DISEASES AND YIELD AFTER DIFFERENT PRE-CROPS

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ABSTRACT

Climate conditions can vary within all growing season, and having a mixture of winter wheat varieties with different adaptive traits allows farmers to better respond to these fluctuations. This adaptability can be crucial in the face of climate change and unpredictable weather patterns. In recent years, various agricultural technologies for plant cultivation have gained popularity, with a focus on practices like reduced soil tillage and continuous wheat sowing. Continuous cultivation of wheat in the same field for a minimum of 2–3 consecutive years significantly influence disease development. Winter wheat mixtures fit well into crop rotation systems, helping to break disease cycles and improve soil health for subsequent crops like corn or soybeans. This study aims to assess the intensity of fungal disease spread in a genetically diverse wheat mixture and evaluate the economic and sustainable farming benefits of using mixed winter wheat cultivars. The inability to effectively control diseases stands as a major factor leading to yield losses. Unfortunately, chemical disease control has reached a threshold of negative residual effects posing threats to water and air quality, natural ecosystems, and human health. Cultivating mixtures of wheat cultivars offers a strategy to better manage fungal disease resistance levels while reducing reliance on fungicides. Several studies indicate that 67 percent of cultivar mixtures have a great potential to decrease fungicide applications compared to winter wheat monoculture. Growing genetically distinct wheat varieties mixtures shows promise in enhancing overall crop conditions when contrasted with mono-crop cultivation. The number and ratio of winter wheat varieties in the mixture positively influence disease reduction and grain yield quality. Research highlights the impact of canopy architecture, encompassing factors like stem count, leaf surface area, and distance reduction in cultivar mixtures. A most crucial aspect if the potential of mixed varieties to diminish the development of fungicide resistance. Increase adoption rates of winter wheat mixtures have been observed globally, indicating farmer satisfaction with the performance and benefits of this innovative agriculture practice. Across four trial sites, cultivar mixtures exhibited a substantial more than 70 % reduction in resistance development to azole fungicides, marking a significant breakthrough. Several studies have shown that, even in the face of weather conditions that vary from year to year, there have been some positive effects from the use of winter wheat mixture technology. Winter wheat mixtures can reduce the intensity of different fungal diseases in the crop by time of 1 to 10 compared to winter wheat mixtures to monocultures. Winter wheat mixtures can also help preserve the potential of different varieties under poor weather conditions. As our studies showed, winter wheat mixtures gave a higher yield of between 0,4 to 0,76 t ha^{-1}, compared to monocultures.

Keywords: winter wheat mixtures, fungal diseases, disease resistance, chemical disease control.

SEED COLOR-DEPENDENT EFFECTS OF COLD PLASMA ON GERMNATION OF RED CLOVER ARE RELATED TO STRONG DIFFERENCES IN THE STRUCTURE OF SEED COAT

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ABSTRACT

Red clover (*Trifolium pratense* L) is a quick growing perennial plant which is used as fodder or medicinal plant and is important for restoration of perennial meadows. It is characterized by a seed color polymorphism so that each seed lot can be classified into 5 classes by the color variating from monochrome yellow (Y) to dark purple (P) as the main colors. We have reported earlier that treatment of red clover seeds with cold plasma (CP) induced stronger stimulation of germination of Y compared to P-colored seeds. Since germination of legume seeds is limited by the seed coat permeability, the aim of this study is to investigate if dependence of CP effects on seed color is related to different structure of the seed coat and CP-induced changes in this structure. For this, we treated Y and P seeds of red clover cv. 2Arimaiciai2 with CP for 7 min (CP7) and analyzed CP-induced changes in seed coat structure and elemental composition using scanning electron microscopy (SEM). The performed SEM analysis revealed substantial differences both in the cross-sectional structure of coat between Y and P seed coat both in control and CP groups. The structure of osteoclereids was typical for Y-coloured seeds only while there was no such structure visible in P-coloured seeds both in control and CP7-treated groups. The results of elemental analysis also revealed essential differences between control and CP7-treated Y and P seeds. In conclusion, cross-sectional SEM analysis has revealed that characteristic dark color of P seeds besides the presence of P pigments is associated with strong differences in the coat structure and in elemental composition as compared to Y seeds. As a result, P seeds build up much stronger permeability barrier compared to Y-ones, so that entirely P seeds without Y spots do not absorb water and are not able to germinate upon imbibition. The obtained results are in line with stronger positive CP7 effects on germination kinetics of Y seeds compared to P seeds.

Keywords: cold plasma, *Trifolium pratense*, seed color polymorphism, scanning electron microscopy, elemental analysis, germination.

MONILINIA SPP. SSR MARKER DATABASE

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ABSTRACT

Freely online available *Monilinia* spp. marker database was created. The database contains microsatellites (SSR) data of the three most essential in Europe fungal pathogens: *M. fructigena*, *M. laxa* and *M. fructicola*. These pathogens cause brown rot blossom blight disease and cause significant losses of stone and pome fruits worldwide. Microsatellites were identified, their distribution was characterized, and SSR markers were designed using the improved bioinformatics tool Genome-wide Microsatellite Analyzing Tool Package (GMATA). The database provides information about SSR markers: forward and reverse sequences of the primer, fragment size, SSR motif, repeat of the motif and the name of the scaffold with the exact location with the coordinates (start and end) of the referenced sequenced scaffold. This database currently contains information about 39 216 SSR from dimeric to hexameric structure, from 10 bp to 36 bp length. For three *Monilinia* species, 26 366 markers are available in the database. This database is the initial start of molecular data organizing, and all scientists can join this collaboration by adding their data. For the check of robustness of *in silico* generated primer, 8 of them were validated experimentally. These primers are highlighted in the database. Moreover, to make the database valuable between different labs, there is possible to add information from other laboratories if primer are validated experimentally. This database is the first molecular marker database worldwide, for *Monilinia* spp. pathogens containing molecular markers data (*Monilinia* spp. marker database: http: http://193.219.178.20). In the future, *Monilinia* spp. marker database would be extended by adding more molecular and genomic information.

Keywords: Database, microsatellites, SSR, molecular markers, *Monilinia* spp**.**

EXOGENOUS PHYTOHORMONES: EVALUATING THE SYNERGISTIC EFFECTS OF PHYTOHORMONES ON PHOTOSYNTHESIS, CAROTENOID SYNTHESIS, SUGAR ACCUMULATION AND YIELD IN PEAS

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ABSTRACT

Plant phytohormones are pivotal regulators of diverse aspects of plant development, playing a crucial role in adaptive processes during both biotic and abiotic stresses. This study aimed to evaluate the impact of exogenous phytohormones on the yield, sugar accumulation, carotenoid synthesis, and photosynthetic response of pea plants. Peas (Pisum sativum L.) cv. Respect was grown in a vegetation area with a shed during the May-July season (lat. 55°, Lithuania). Five different phytohormones (kinetin (KIN), indole-3-acetic acid (IAA), gibberellic acid (GA_3), abscisic acid (ABA), and salicylic acid (SA)) were selected and a combination of two phytohormones per treatment was applied at a concentration of 30 mg L^{-1}. Exogenous phytohormones were applied at critical development stages: at 14-16 and 51-55 BBCH. Analyses were conducted five days after application and at technical maturity. The results indicated that combinations of IAA+ABA and GA+SA demonstrated an improvement in plant productivity, although metabolic response differs between synergistic and antagonistic relationships between phytohormones.

Keywords: exogenous phytohormones; pea; biostimulants; photosynthesis; productivity; onthogenesis

IMPROVING MAIZE GRAIN YIELD PREDICTION COMBINED FIELD MEASUREMENTS WITH UAV MULTISPECTRAL IMAGERY AND MACHINE LEARNING

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ABSTRACT

Quick and accurate prediction of crop yield helps to optimize farm costs and at the same time make more accurate economic decisions to obtain the planned harvest yield. Recently, unmanned aerial vehicles (UAVs) equipped with multispectral sensors have emerged as a powerful tool for collecting remote data. These data combined with field measurements and machine learning allow to predict a wide range of qualitative and quantitative plant parameters. Field experiments with a short-season grain maize variety Conclusion (FAO 190) were conducted in 2023 at two contrasting soils (luvisol and arenosol). The experimental design included 13 treatments with different fertilization levels including different types of fertilizers (mineral, organic fertilizers, and a combination of them). UAV campaigns were carried out five times during the main maize growth stages (V5, V10, VT/R1, R3, R6) Obtained multispectral remote data and recalculated vegetative indices (NDVI, NDRE, SAVI, GNDVI, NGRDI) in combination with field measurements (spad index, chlorophyll fluorescence Fv/Fm ratio and plant height) were used to create machine learning models. Three machine learning algorithms were used for creating maize yield prediction models: Linear model, Random Forest, and Cubig. In addition, to improve maize yield prediction, we used three data sets with different independent variables,1- using only spectral bands values,2- spectral bands values and vegetative indices, and 3 spectral bands values, vegetative indices, and field measurements data. The simulated results have shown that in most cases, the inclusion of vegetative indices and field measurement variables to the model input data sets improves the accuracy of the grain yield prediction in terms of coefficient of determination (R^2) and root mean square error (RMSE), which increased from 0.68 to 0.93 in the Akademija field and from 0.73 to 0.84 in the Ruosciai field. At the same time, RMSE values decreased from 0.86 to 0.39 in the Akademija field and from 0.92 to 0.59 in the Ruosciai field. The most suitable time for predicting maize grain yield in both fields was the milk-R3 maize growth stage.

Keywords: machine learning, maize, grain yield, unmanned aerial vehicles, vegetation index.

MICROBIOME DIVERSITY IN BUDS OF PLUM GENOTYPES DIFFERING IN THEIR RESISTANCE TO BROWN ROT DISEASE

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ABSTRACT

Metagenomics is known for its important role in microbiota research, as it deciphers uncultured microbial populations found in the environment. The aim is to fully characterize the structure of the community, the functional activity of individual microbial members, and the heterogeneity between species. Plant-associated microbes play an important role in plant development and response to exogenous stress. Microorganisms can engage in a variety of complex interactions ranging from antagonism to mutualism, which can result in positive or negative co-occurrence across samples. In addition, two microorganisms can co-occur if they exhibit highly similar or different growth responses to altered environments independent of any direct microbe-microbe interaction. Co-occurrence can thus be positive or negative and is jointly controlled by direct interactions between microbes, niche processes across environmental variation, and differential dispersal among taxa. The most important ecological niches within the plant microbiome include the rhizosphere, the phyllosphere, the caulosphere, the anthosphere, and the carposphere. The type of compartment is the main determinant of microbial diversity, structure, and abundance. Each compartment has its peculiarities that can be beneficial or limiting factors for certain microbiota. Usually, below-ground samples are richer than the phyllosphere. This could be the reason why most studies on the plant microbiome have focused on the root system, while studies on other plant organs have been rather rare. Therefore, the aim of this study was to investigate the diversity of the microbiota in buds of plum genotypes that differ in their resistance to brown rot.

Microbial profiles can be obtained either by shotgun sequencing of genomes or through amplicon sequencing of target genes (e.g. 16S rRNA for bacteria and ITS for fungi). In this study, amplicon sequencing was used to assess the bacterial and fungal communities during the overwintering phase of plum buds. A total of seven different plum genotypes were selected according to their resistance to brown rot (one highly resistant genotype, three resistant genotypes, and three susceptible genotypes). Approximately 20 buds of each genotype were randomly sampled with three technical replicates and metagenomic analysis was performed. Alpha and beta diversity, composition, core microbiota, and linear discriminatory analysis results were compared. The beta diversity showed that only the susceptible and highly resistant plum genotypes differed significantly in the bacterial communities. The situation was different when comparing the fungal communities, where all groups of genotypes showed significant differences. The most common bacterial genera in all genotypes were *Sphingomonas*, *Methylobacterium*, *Hymenobacter*, and 1174-901-12, while the most common fungal genera were *Taphrina*, *Seimatosporium*, *Microcyclospora*, *Cladosporium*, *Aureobasidium*, and *Alternaria*. There was also another unidentified genus (noted as *incertae sedis*) that was present in all genotypes. The core microbiota across different plum genotypes consisted of a slightly higher prevalence of bacteria than fungi. The results of this study correspond to the results of Serbian plum leaves and fruits, which showed a similar composition of bacterial communities. These results are the first insights into the microbiota of Lithuanian plum orchards. Further studies of the composition of microorganisms in the soil of plum trees could help to better understand the differences between the different plum tree genotypes.

Keywords: metagenomics, plum buds, bacteria, fungi, brown rot.

EFFECTS OF DIFFERENT MINERAL FERTILIZERS AND SOWING DENSITIES ON CANNABIDIOL CONTENT AND BIOMASS DISTRIBUTION OVER DIFFERENT PARTS OF HEMP (*CANNABIS SATIVA* L.)

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ABSTRACT

Since the demand for pharmaceutical hemp increased, selecting the optimal sowing density, fertilizer combinations, and application rates has become a significant issue. In pharmaceutical hemp crops, different plant parts like highly valuable seeds and stalks can be utilized as well. Therefore it is important to assess the impact of various crop treatments on the optimal value of the hemp crop. Cannabis sativa is known for its ability to adapt and grow in various conditions. Shading and competition from other plants have a great impact on the morphology and phytohormonal balance of the plants that may have effects on secondary metabolism qualitative and quantitative composition of biologically active compounds such as cannabinoids in cannabis sativa. However, the nutrient requirements may vary among hemp crops of different densities, underscoring the need for tailored agronomic practices to optimize both crop yield and quality.

We conducted a three-year field experiment to assess the effects of two sowing densities: 16 and 32 plants per square meter, and different treatments with mineral fertilizers: 0 (control), N_{120} (ammonium nitrate), $P_{100}K_{100}$ (superphosphate and potassium chloride), $N_{120}P_{100}K_{100}$ (combining ammonium nitrate, superphosphate and potassium chloride) on concentrations of cannabidiol (CBD) in inflorescences of hemp and dynamics of different hemp parts: stems, leaves, inflorescences and seeds.

Our findings indicated that planting densities did have a significant impact on the concentrations of cannabidiol in the unfertilized hemp fields, however, the differences were minor. A higher significant negative effect was found in the treatments fertilized with N_{120} and $N_{120}P_{100}K_{100}$. The differences between the two densities fertilized with $N_{120}P_{100}K_{100}$ were significant but yet minor. Application of $P_{100}K_{100}$ fertilizers significantly increased the concentrations of cannabidiol in the inflorescences of the lower and the higher density hemp fields.

The fertilization of N_{120} and $N_{120}P_{100}K_{100}$ significantly increased the final stem, leaf, inflorescence, and seed yield however there were no significant differences between these two treatments both in lower and higher density fields. The increase in stem, leaf, inflorescence, and seed yields was more substantial in lower density fields. N_{120} and $N_{120}P_{100}K_{100}$ primarily increased the stem and leaf yield compared to control treatment, the improvement of inflorescences and seed yields was modeg. Application of $P_{100}K_{100}$ significantly reduced the stem, leaf, inflorescence, and seed yields in both the lower and the higher density fields compared to the control treatment.

Keywords: Hemp, Cannabis sativa, cannabidiol, CBD, density, mineral fertilizers, nitrogen

IMPACT OF COLD PLASMA SEED TREATMENT ON PHYTOCHEMICAL CONTENT OF STEVIA REBAUDIANA BERTONI CULTIVARS

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ABSTRACT

Stevia rebaudiana Bertoni is a zero-calorie natural sweetener, being 10-15 times sweeter than sucrose. When consumed, it has shown to have therapeutic benefits [1]. Apart from steviol glycosides, the leaves of stevia are also known for their antioxidant properties, which are possibly related to a rich profile of various phenolic compounds [2]. The highest economic importance lies in steviol glycosides (SGs): stevioside (Stev) and rebaudioside A (RebA), being the most abundant. Increase in Stev, RebA and their overall ratio is closely linked to sweetness intensity and pleasantness of taste.

The aim of this study is to determine the effect of seed treatment with two types of cold plasma on phytochemical biosynthesis in two *S. rebaudiana* cultivars (SHUG A3-6 and SHUG HIGH A3, EverStevia, Canada). Previous studies indicate that the effect varies in cultivars. Seeds were treated with plasma using low-pressure capacitively-coupled (CC) and atmospheric-pressure dielectric barrier discharge (DBD) systems for durations of 2, 5, and 7 minutes prior to sowing. Eight-week-old plant leaves were collected and dried, and extracts were prepared for the analysis of steviol glycosides, total phenolic compounds (TPC) determined using Folin-Ciocalteu (FC) reagent, total flavonoid compounds (TFC) determined using the aluminum compound formation reaction, and antioxidant activity determined as DPPH radical scavenging capacity. Stev, RebA, and other SGs were measured using High-Performance Liquid Chromatography (HPLC).

Our results indicate that treatment with cold plasma (CP) can enhance secondary metabolite biosynthesis and therefore improve stevia traits. A two-fold increase in stevioside, as well as a statistically significant increase in TPC and antioxidant activity, was observed in SHUG A3-6 treated with CC for 5 minutes. SHUG HIGH A3 showed an increase in stevioside in all experimental groups, but it was not as drastic as in SHUG A3-6. The obtained results correlate with each other, where an increase in Stev is followed by a decrease in RebA and an increase in TPC, TFC and antioxidant activity in both cultivars, respectively. It seems that CP treatment affects the overall biochemical composition. It is important to understand that numerous factors influence the biosynthesis of phytochemicals, including the specifics of the plasma system, duration of plasma exposure, growth conditions, cultivar characteristics, among many others. Further research is needed to confirm specific influencing factors of CP treatment.

Keywords: *Stevia rebaudiana* Bertoni, steviol glycosides, antioxidant activity, phenolic compouds, flavonoids

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PRELIMINARY RESULTS OF HYPERSPECTRAL IMAGE ANALYSIS OF FUSARIUM HEAD BLIGHT ON OATS

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ABSTRACT

Small grain cereals - wheat (*Triticum aestivum* L.), rye (*Secale cereale* L.), oat (*Avena sativa* L.), and barley (*Hordeum vulgare* L.). are one of the most important groups of crops in Europe and the Baltics. These crops are exposed to various diseases caused by pathogenic fungi (e.g. *Blumeria graminis, Parastagonospora nodorum*, *Puccinia* spp., *Zymoseptoria tritici*, *Fusarium* spp., *Rhynchosporium secalis, Pyrenophora* spp., etc.), and timely detection of diseases is very important for effective plant protection in farming. Farmers mainly rely on the visual assessment of diseases symptoms on-site, but this method has several significant limitations. Various precision farming methods are stepping into everyday farming practice, one of them is hyperspectral image (HI) analysis, combined with unmanned aerial vehicles (UAVs), which potentially provide a solution for fast, non-destructive, and scalable disease assessment in different crops. Hyperspectral measurements can reveal a relationship between the spectral reflectance properties of plants and their structural characteristics, pigment concentrations, water level, etc., which are considerably influenced by biotic plant stress. Hyperspectral sensors measure up to several hundred bands of the electromagnetic spectrum in the wavelength range from visible light to short-wave infrared spectrum (400 - 2500 nm). Each pixel in a hyperspectral image obtains a distinct set of information about the reflectance/transmittance at each spectral band and the sum of this information is called a spectral signature or spectral profile.

As part of PhD research, greenhouse trials were conducted on oats - seedlings were inoculated with *Fusarium* spp. spore material at different stages of plant development. The highest disease rates were obtained when the plants were sprayed with the inoculum material at the early mid boot development stage (BBCH 41-43). The obtained HIs allows to distinguish diseased heads from healthy ones. In the further senescence stages, the spectral differences between diseased and healthy heads disappeared, although microbiological tests confirmed that the diseased plants still contained fungal pathogens. The possible reason for this effect is that the rate of the disease is low and the spectral changes of heads due to senescence overtake previous spectral changes caused by disease. More trials are planned to verify the obtained results, including analysis of different levels of pathogenicity.

Keywords: Hyperspectral imaging, oat, fusarium head blight, mycotoxins.

CH_4 AND N_2O EMISSIONS FROM DRAINED AND UNDRAINED PEATLANDS

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ABSTRACT

Histosols cover about 8–10% of Lithuania's territory and most of this area is covered with nutrient-rich organic soils (*Terric Histosols*). Greenhouse gas (GHG) emissions from drained *Histosols* contribute more than 25% of emissions from the Land Use, Land Use Change and Forestry (LULUCF) sector.

In this study, we examined CH_4-C and N_2O-N emissions in drained and undrained forested *Terric Histosols* during 2021-2023.

The samples of CH_4-C and N_2O-N gas were collected in drained and undrained forested organic soils (*Terric Histosols*) with non-transparent chambers (65 L) 2-3 times a month during the growing season and once a month during the cold season. Three subplots for CH_4-C and N_2O-N gas measurements were established in each study site. The distance between subplots was 30 m. Samples were collected 4 times in one hour (after 1 min, after 20 min, after 40 min and after 60 min). The collected samples were analysed by gas chromatography in the laboratory of the University of Tartu (Estonia).

The emissions of CH_4-C had negative values and no clear variations in drained afforested *Terric Histosols* during the different months over the year. However, the highest emissions of CH_4-C released from undrained forested *Terric Histosols* during summer months and reached average value of 40 kg ha^{-1} per month. Meanwhile, the emissions of N_2O-N from drained *Terric Histosols* were the highest during vegetation period and reached monthly in average 2 kg ha^{-1}. However, in undrained *Terric Histosols* N_2O-N emissions released when the groundwater level has decreased, and N_2O-N not exceeded 1 kg ha^{-1} per month.

NITROGEN fIXATION EFFICEINCY OF SYMBIOTIC AND ASSOCIATIVE BACTERIA IN GREENHOUSE AND FIELD CONDITIONS

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ABSTRACT

Soybean, also known as *Glycine max* (L.), is one of the most essential grain legume crops globally due to its high protein and oil content. To achieve optimal growth and yield, soybeans form a symbiotic relationship with rhizobia bacteria that resides in root nodules and convert atmospheric nitrogen into a usable form for the plant. The aim of our study was to select locally isolated and commercial associative microorganisms which effectively promote nitrogen fixation in soybean root nodules. For this purpose, natural occurring endophytic and exophytic bacteria screening was done for soybean plants growing at LAMMC Geographical coordinates for the field location are 65–75 meters above sea level and 55°23′50″North, 23°51′40″East in 2022. Ten endophytes out of 160 were selected as promising for nitrogen fixation increase in soybean plants. A greenhouse experiment was conducted to test the effects of these endophytes on 2022-2023. To evaluate the nitrogen amount derived from the air, the soil was fertilized with ammonium nitrate (NH_4NO_3) solution, containing labelled stable ^{14}N isotope. Our results showed that 4 endophytes: *Arthrobacter pascens, Serrartia inhibens, Bacillus velezensis,* and *Serratia plymuthica* stimulate the higher leaf chlorophyll content, fluorescence parameters and net photosynthesis rates compared to the control at different stages of soybean growth. Based on the analysis of fresh and dry biomasses of roots and shoots of soybean plants, it has been found that these microorganisms also show the best effect on soybean productivity. However, comparing the effect of endophytes, none of these had the effect as symbiotic nodules forming bacteria *Bradyrhizobium japonicum*. The effect of endophytes was from 34 to 76 percent part of the effect exposed by B. japonicum. Based on these results the field experiment was established to compare the effect of our selected endophytes with the commercial ones from all the Europe. These data will be very important for farmers and also the scientists, since in Lithuania, under temperate climate conditions there was no soybean endophytes screened yet.

Keywords: Soybean, Symbiotic relationship, rootnodules, Bio stimulants, greenhouse Nitrogen fixing bacteria

DRYING TECHNIQUES AND PHENOLS OF MUSHROOMS AND MYCELIUM PRODUCTS

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ABSTRACT

Mycelium is the thread-like network of hyphae that makes up the vegetative part of a fungi as well. It is typically underground or inside its substrate, and it is responsible for absorbing nutrients from the surrounding environment and transporting them to the fruiting bodies. Mycelium is very important for the growth and development of fungi, and it can also help to break down organic matter and recycle nutrients in the substrate. Mushrooms and mycelium products are gaining increasing popularity due to their high nutritional value and potential health benefits. It is a rich source of nutrients, including vitamins, minerals, proteins called mycoproteins and bioactive compounds, such as phenols. Phenols have been shown to have a wide range of health benefits, including antioxidant, anti-inflammatory, and antimicrobial properties. Mycoproteins are a type of protein derived from mushrooms. Mycoproteins are a popular ingredient in meat alternative products. The conducted studies and research showed that 20-25% proteins can be found in the composition of micellar products. However, the preservation of these products is crucial to maintain their quality and prevent the degradation of their bioactive compounds, such as phenols.

In this research the optimal drying method will be chosen for preserving the phenolic compounds content of mushrooms and mycelium products. The influence of different drying methods on the biochemical and physicochemical properties of the substrate and mycelium were compared.

The total phenolic concentrations before and after drying proceudres were examined in a samples determined by the Folin-Ciocalteu reagent in ethanol/water extract (70/30, v/v %) from different samples. The physicochemical paarmeters were analysed: dry matter content was determined by moisture analyzer, total soluble solids were determined using a digital refractometer, pH was measured using a pH meter and color characteristics were evaluated using a CIEL*a*b* system.

In summary, drying technology is a widely used preservation method for mushrooms and mycelium products, but the choice of drying method can significantly impact the phenolic content of the dried product. Properly dried mushrooms and mycelium products can be stored for extended periods without significant loss of their nutritional and health-promoting properties.

Keywords: mushrooms, mycelium, substrate, drying, phenols, mycoproteins.

3.2. Pest Management and Food Safety

EVALUATION OF CHEMICAL COMPOSITION OF HEMP AND PUMPKIN BY-PRODUCTS

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ABSTRACT

The ongoing trend of valorising agri-food waste and by-products aligns with the global initiative towards sustainable development. Notably, the hemp and pumpkin oil industries generate substantial by-products, often discarded or used as animal feed. The current environmental challenges have prompted researchers and industries to invest efforts addressing these issues. This research investigated the chemical composition of pumpkin seed meal and various by-products from the hemp oil industry, including press cake, hulls, and herbs. Proximate composition analysis was followed by supercritical CO_2 extraction to isolate lipophilic compounds. Gas chromatography was employed to analyse the fatty acid composition of the obtained extracts. The findings revealed that press cakes from both pumpkin seed and hempseed are rich in protein, measuring 45.39 % and 31.08 %, respectively. In addition, it was observed that the application of supercritical CO_2 for defatting had also enhanced the nutritional quality, particularly in terms of protein and carbohydrates. For instance, the level of protein yield varied from 11.62 % before defatting to 12.31 % after defatting for hemp leaves. The fatty acid profiles of hempseed by-products displayed an important amount of linoleic acid (LA), α-linolenic acid (ALA), and oleic acid (OA), mainly for press cake extract. This study demonstrated the potential of by-products from pumpkin and hemp oil industries as promising candidates for the development of innovative food products.

Keywords: By-products, Hemp, Pumpkin, Valorisation, Proximate composition, Food industry

SUSTAINABLE RENEWABLE PIGMENTS FROM FRUITS AND VEGETABLE BY-PRODUCTS FOR POLYDIMETHYLSILOXANE

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ABSTRACT

Fruits and vegetables are important sources of organic compounds. Over 70% of fruits and vegetables are wasted together in the food chain, consequently being the foodstuffs with the highest level of waste. This study presents a novel research project that used naturally occurring, biodegradable pigments that were obtained from processed fruit and vegetable waste to transform industrial polymer coloration. This project targets the persistent issue of plastic waste and the critical environmental threats posed by conventional synthetic pigments with a dedication to sustainable innovation and to be a part of the European Green Deal (EGD) strategy. The approach used in the research comprises the extraction and characterization of pigments (Carotenoids, anthocyanins , and betalains) from frequently disregarded by-products produced during regular fruit and vegetable processing and then incorporated in the PDM matrix. Pigments from fruit extract contain antioxidant and antimicrobial properties. PDMS is a synthetic organosilicon polymer that has been used since the 19's, due to its transparency, flexibility, easy fabrication, physical and chemical stability. The aim of this study was to modify a PDMS with natural pigments and investigate the influence of filler on the polymer matrix. In this work, PDMS/Beetroot were characterized for their structure, surface energy, and morphology. Composites morphology was characterized by SEM. The contact angle measurements were peformed at room temperature (23 °C) using a sessile drop method. One droplet of deionized water (~5 mL) was deposited on the sample surface. From the microscope studies (SEM) analysis of PDMS/Beetroot and PDMS/Beetroot showed rough surface. Contact angle presents that filler influences hydrophobicity, when filler increases the contact angle decreases. The hydrophobic properties of the polymer are reduced due to the natural hydrophilic nature of the filler.

Keywords: polymers, green synthesis, extraction techniques, by-products, fruits and vegetables pigments

EVALUATION OF THE CHEMICAL COMPOSITION OF QUINCE AND CAPE GOOSEBERRY SEEDS

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ABSTRACT

Cydonia oblonga Miller (Quince Seeds) is part of the Rosaceae family, a small shrub native to Southwest Europe and parts of Asia, including Iran, Afghanistan, Turkey, China, Uzbekistan, and Morocco. This provides a concise botanical and geographical backdrop. It mentions the traditional use of quince seeds as a demulcent and their applications in treating asthma and coughing. Mucilage is a group of biopolymers derived from various plants, including *Cydonia oblonga Miller* (quince seeds) extensively utilized in pharmaceutical manufacturing for its binding, thickening, stabilizing, humidifying, disintegrating, suspending, emulsifying, and sustaining properties. *Physalis peruviana* L., known as Cape Gooseberry or Goldenberry, is a key commercial species of the *Physalis* genus, appreciated for its exotic fruit. Gaining popularity worldwide, including in tropical, sub-tropical, and temperate regions like Europe, Asia, Africa, and the Americas, its appeal lies in its unique taste, nutritional value, and versatility in culinary uses. Cape Gooseberry (CG) fruit's rising popularity can be attributed to its combination of attractive appearance, enjoyable taste and aroma, and significant nutritional and health benefits. It's rich in phytonutrients and bioactive compounds, which contribute to its potential antidiabetic, anticholesterolemic, hepatoprotective, anti-inflammatory, and immunomodulatory effects, among others. Additionally, the CG fruit is valued for its high yield and the profitability it offers to farmers, making it an appealing crop commercially. This multifaceted appeal has led to its increased cultivation and consumption across the globe.

This study investigates the potential of Quince Seed (*Cydonia oblonga*, QS) and Cape Gooseberry (*Physalis peruviana*, CG) seeds as sources of valuable oils and phytochemicals. Initial analyses focused on determining the moisture and ash content of the seeds, revealing moisture levels of 4.74% for QS and 4.22% for CG, and ash content of 2.43% and 3.08%, respectively. These parameters are essential for assessing the seeds' quality and purity, providing a baseline for further analysis. The extraction of lipophilic components was conducted using supercritical CO_2 extraction at high pressure, a method chosen for its efficiency and ability to preserve the integrity of the extracted compounds. The yields from this process varied significantly, with QS producing a 1.42g-4.52g Yield, g/100g with a time of 15-165 minutes, and CG a more substantial 2.74g-17.70g Yield, g/100g with a time of 15-195 minutes, indicating a higher potential in CG for oil extraction.

Additionally, the Soxhlet extraction technique was employed to determine the overall oil content in both seeds. The results showed an average oil content of 6.41% for QS and 11.12% for CG, suggesting that Cape Gooseberry seeds are a richer source of oil compared to Quince Seeds. The variations observed in oil yield and composition highlight the importance of these seeds as underutilized sources of unsaturated fatty acids and other phytochemicals with potential health benefits. This study underscores the value of QS and CG seeds in producing essential oils and suggests further research into their applications in the food, cosmetic, and pharmaceutical industries. This study highlights the potential of Quince Seed (*Cydonia oblonga Miller*) and Cape Gooseberry (*Physalis peruviana* L.) seeds as valuable sources of oils and phytochemicals. Through moisture, ash content analysis, and oil extraction methods, it was found that Cape Gooseberry seeds are particularly rich in oil, suggesting their significant underutilized potential. The findings open avenues for the application of these seeds in the food, cosmetic, and pharmaceutical industries, underlining their economic and health benefits. Future research could further explore the specific advantages and commercial opportunities offered by these plant-derived oils.

Keywords: Gooseberry (CG), Quince Seed (QS), supercritical fluis extraction, proximate composition

TILLAGE INFLUENCE ON SOIL CONDITIONS AND CO_2 EFLLUX FROM DIFFERENT CROPPING SYSTEMS DURING CROP GROWING SEASON

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ABSTRACT

The atmospheric concentration of greenhouse gases has been increasing considerably in recent years because of anthropogenic activities. Carbon dioxide (CO_2) is the most important anthropogenic greenhouse gas, because roughly 20% of global CO_2 emissions in the atmosphere originate from soil. Seasonal emission of CO_2 from soils could be influenced by changes in weather, tillage, soil coverage with plants and crop diversification. Tillage management can increase atmospheric CO_2 concentrations and contribute to global warming, but it is uncertain to which extent different tillage methods enhances the transfer of soil CO_2 to the atmosphere. Although cropping systems diversification including catch crops is described as an effective long-term strategy for carbon storage in the soil, but there are still many questions how catch crops affect CO_2 emissions. The aim of this study was to compare soil CO_2 efflux variation under different tillage and cropping systems management in relation to soil temperature and moisture regimes during crop vegetation period.

The field experiment was initiated at the Institute of Agriculture, LAMMC (Central part of Lithuania) in 2021 and consisted of conventional tillage (CT) and no-tillage (NT) treatments. A five three-course crop rotations: 1) WW+SW+WW; 2) WW-CC+SW+WW-CC; 3) SW-CC+P +SW; 4) SW-CC+P-CC +WR; 5) WR-CC+SW-CC+P-CC were investigated in the field trial. Winter wheat (*Triticum aestivum* L.(WW)), spring wheat (*Triticum aestivum* L.(SW)), field pea (*Pisum sativum* L.(P)) and spring oil-seed rape (*Brassica napus* L.(SR)) was included in the rotation and varied depending of the year of growing. The different plants species were selected with the aim to evaluate as diverse crop rotations as possible, taking into account the share of legumes in the crop rotation and the inclusion of catch crops. White mustard (*Sinapis alba* L.) was as a catch crop (CC). The soil in the experimental field was classified as *Endocalcary-Endohypogleyic Cambisol* of a loam texture. Soil CO_2 emissions (μmol m^{-2} s^{-1}) were measured in a 0–10 cm soil layer with a portable analyzer Li-Cor 6400-09 during plant vegetation period in 2021 - 2023. Soil temperature and soil moisture were measured at 5 cm depth using a portable sensor HH2 WET at the same time in a fixed locations as for CO_2 efflux measurements. As our results indicated, tillage was a significant factor in soil CO_2 emissions in all crop rotations. In no-till treatments, CO_2 emissions were found to be significantly greater (by 28%) compared to CT. It was noted that soil temperature and large precipitation events were an important factor in determining soil CO_2 emission variations, which could lead the differences between the changes in CO_2 emissions by 2-3 times, especially from NT. Crop rotation was determined as a factor controlling soil CO_2 release from soil due to their distinct root development patterns and nutrient acquisition mechanisms. The rotation of winter wheat-CC + spring wheat + winter wheat-CC showed the highest CO_2 effluxes, particularly in NT. Crop rotation incorporating CC increased CO_2 fluxes by 8-38 %. NT system also retained more moisture than conventionally tilled soils. Tillage became less significant in modulating soil temperature, nevertheless, a trend towards higher soil surface temperatures in CT was noticed, which could be decisive due to increased air circulation in the soil pores. The tillage-induced soil CO_2 emissions appeared to be dependent on changes in soil microclimate (temperature and moisture) conditions as their correlation with soil CO_2 emission was moderate (0.44, $p < 0.05$) or strong (-0.73, $p < 0.05$). It had been registered that increase in CO_2 emissions depend negatively on soil moisture content, while was positively related with soil surface temperature increase. Data collected in this study may assist to improve the assessment of CO_2 emissions under different cropping systems application from *Cambisol* at field-scale conditions and support greenhouse gas mitigation strategies.

Keywords: Soil, CO_2 emissions, tillage, crop rotations, catch crops, soil moisture, air temperature.

THE SEARCH OF NEW BACTERIOCINS ACTIVE AGAINST PHYTOPATHOGENIC BACTERIA

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ABSTRACT

Emerging plant diseases caused by phytopathogenic microorganisms are a matter of great importance, since they regulate not only food quality but also availability, affect soil ecosystems. As for major crops, such as maize, rice, wheat, potatoes and soybean, the global annual loss is reaching from 17 to 30% [1]. Currently, antibiotics and other chemicals are the most widely used tools in plant protection against phytopathogens. While these compounds have the desired and rapid effect, they accumulate, run off into water sources and are harmful to local ecosystems and natural soil microbiota [2]. Thus, alternatives need to be found to reduce the losses caused by plant pathogens and the effects of the compounds used to eliminate crop diseases. One of the alternatives with great potential is bacteriocins - ribosomally synthesized antibacterial peptides, which inhibit the growth of closely related or, in certain cases, a broader range of bacteria species [3]. The inhibitory activity of these proteins can be used to process fruit, vegetables, or seeds by coating them with a layer of bacteriocins to prolong their shelf life and protect them against diseases [4]. The use of bacteriocins as antimicrobials can not only help to reduce yield losses, but also reduce soil degradation caused by the use of harmful substances.

The aim of this study was to find bacteriocins secreted by bacteria that can inhibit the growth of certain phytopathogenic bacteria and to extract and identify these antimicrobial peptides. The total of 157 isolates were obtained from the soil samples, and they were screened in order to evaluate their antibacterial activity against 9 phytopathogens. Using agar diffusion method, we selected 9 out of 157 isolates that had inhibitory activity against at least two of the phytopathogenic strains. Furthermore, the antibacterial activity of the supernatant of the isolates was tested using agar well diffusion teg. Isolate strain KP7 showed the best activity, thus further protein purification and protein analysis was carried out and is described in this study. The results of 16s rRNA gene analysis revealed that this bacterium can be classified as *Bacillus velezensis*.

Keywords: biocontrol; sustainable strategies, bacteriocins, plant pathogens, antimicrobial peptides

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HEALTH RISK ASSESSMENT OF HEAVY METALS IN CHINESE TEAS CONSUMED BY POLISH POPULATION

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ABSTRACT

Tea consumption is widely popular, with consumers embracing diverse varieties of teas. However, the safety of these beverages is of paramount concern, particularly regarding heavy metal contamination. This study addresses the potential health risks associated with the consumption of five types of Chinese tea, namely oolong, Pu-erh, flower, and green tea (2 types). The focus of the study was on the metal content in tea infusions and the related human health risks resulting from their consumption.

The contents of As, Cd, Cr, Cu, Co, Fe, Mn, Ni, Pb, Sb, Sn, Tl, and Zn were determined using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) in the first and second tea infusions as well as in tea leaves. To determine the total contents of the elements investigated, the test portions of 0.5 g of tea leaves were placed in mineralization flasks, watered with 15 cm^3 of HNO_3 and 5 cm^3 of H_2O_2, and allowed to undergo organic matter decomposition overnight. Subsequently, digestion was performed using the SCP Science DigiPREP HT High-Temperature Digestion System (SCP Science, Quebec, Canada) at 130 °C for 2 hours. After the extract solutions cooled, their volumes were increased to 50 cm^3 by incorporating ultrapure water. The two tea infusions were prepared for analysis. For I infusion 2g of tea leaves were brewed for 2-3 minutes with ultrapure water at 80-90°C, followed by filtration through a paper filter. The remaining leaves were brewed with ultrapure water at 70°C for the next 2-3 minutes.

Heavy metal concentrations were subjected to statistical analysis involving the determination of mean, standard deviation, minimum, and maximum values using the STATISTICA software package (TIBCO Software Inc., PaloAlto, CA, USA). The point estimate method developed by USEPA was applied for the Human Health Risk Assessment (HHRA) arising from the consumption of investigated heavy metals in Chinese tea beverages consumed by Polish consumers.

The findings contribute to understanding the potential health risks posed by the heavy metal content in the teas consumed. This research is an introduction to more extensive research on whether the heavy metal content depends on the type of tea and, therefore, on the related health risks for their consumers.

Keywords: health risk assessment, tea infusion, tea leaves, tea consumption, tea consumer, human health, potentially harmful elements

EXTRACTION OF BIOACTIVE COMPOUNDS FROM *ASTRAGALUS GLYCYPHYLLOS*: INNOVATIVE METHODS AND ANTIOXIDANT EVALUATION

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ABSTRACT

Astragalus glycyphyllos, a perennial plant belonging to the Fabaceae family, is indigenous to Europe and Asia. Its distinctive legume-like appearance has led to its colloquial nickname "eagle's claws" in Bulgaria. Throughout Europe and Asia, this plant has a long history of traditional medicinal use, being utilized to treat a range of conditions such as urinary and gastrointestinal issues, skin disorders, rheumatism, and high blood pressure.

The aim of this work is to isolate bioactive compounds from *Astragalus glycyphyllos* plants collected at different growth periods using different innovative extraction methods and to evaluate the antioxidant capacity of the obtained extracts. *Astragalus glycyphyllos* was firstly defatted by supercritical fluid extraction with carbon dioxide (SFE-CO_2). The leaves were further extracted by two novel methods: pressurised liquid extraction (PLE) and ultrasound assisted extraction (UAE) using two solvents of different polarity. PLE applies high pressure and temperature to increase extraction efficiency, while ultrasound assisted extraction uses sound waves to disrupt plant cell walls and facilitate the release of compounds. The extracts obtained were evaluated by various antioxidant capacity tests: 2,2-diphenyl-1-picrylhydrazyl free radical (DPPH°) and oxygen radical absorbance capacity (ORAC) assays, and total phenolic content was determined by Folin-Ciocalteu. The yields of the lipophilic fractions obtained by SFE-CO_2 ranged from 0.9 to 1.4 % depending on the growth period. The results showed that the yields of the extracts extracted from *Astragalus glycyphyllos* plants by PLE and UAE increased with increasing solvent polarity and there were no significant differences between the different growth periods. The extracts obtained also showed good antioxidant activity.

It can be concluded that the successful extraction of valuable bioactive compounds from the leaves of *Astragalus glycyphyllos* using innovative methods has shown that these methods can be applied to a wide range of botanical species. These methods are a promising way to further investigate and improve the extraction and fractionation processes of various plant materials.

Keywords: *Astragalus glycyphyllos*, pressurized liquid extraction, ultrasound assisted extraction, antioxidant capacity

APPLE TREE ORCHARD SOIL FATIGUE OF REPLANT SITES

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ABSTRACT

Specific apple replant disease (SARD) is a big problem in horticulture worldwide, primarily in countries with a well-developed fruit-growing sector. The difficult etiology of the disease led to limited progress in the development of soil recovery measures. The SARD affects the growth and development of apple trees and decreases yield and fruit quality. In addition, it can increase plant susceptibility to typical diseases. New apple orchards due to the limited areas of available land are usually replanted in the same place, and there is no time for the natural recovery of soil microbiota. The choice of chemicals for soil remediation is limited, and getting smaller as the European Union targets reducing chemical pesticides by 50% by 2030. Therefore, searching for effective and less harmful soil treatment measures is important. Previous studies have shown that the SARD is caused by biotic factors, in particular, microorganisms. The studies on soil microbiota suggested that various genera of fungi, oomycetes, actinomycetes, and bacteria with different dominance in the soil may be involved in this complex disease. Different micromycetes can be found in different regions and soil types. Soil microbiota also can be affected differently by exposure to particular substances. Our future research will focus on the composition of soil microbiota in apple tree orchards, identification of the dominant microorganisms that may cause SARD, and search for possible means for mitigation of replant problems. Environment-friendly means such as biocide, biostimulator, soil activators, or biofertilizers are intended to be used for the recovery of soil properties.

Keywords: specific apple replant disease, soil, microbiota, pathogens.

ANTIOXIDANT ACTIVITY OF *DIOSCOREA CAUCASICA* AND *DIOSCOREA NIPPONICA* LEAVES, ROOTS AND THEIR EXTRACTS

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ABSTRACT

Dioscorea nipponica Makino and *Dioscorea caucasica* Lipsky plants belong to Dioscoreaceae family. The genus consists of more than 600 species native to Africa, Asia, the Caribbean, South America, and the South Pacific Islands. Dioscorea plants are rich in steroids, quinones, cyanides, phenols, diterpenes, diarylheptanoids, and nitrogen-containing compounds. One of the most important bioactive compounds diosgenin possesses various biological effects, including antioxidant, hypoglycemic, hypolipidemic, antimicrobial, inflammatory, antiproliferative, androgenic, estrogenic, and contraceptive properties. To sum up, *Dioscorea* spp. is a potential source of bioactive substances for the prevention and treatment of several diseases. However, ultrasound-assisted extraction (UAE) and pressurized liquid extraction (PLE) have not been used to recover bioactive compounds from *D. nipponica* and *D. caucasica* leaves and roots.

This study aimed to compare the extracts obtained by PLE and UAE antioxidant activity of D. *caucasica* and *D. nipponica* leaves and roots. The plants were grown in the collection of medicinal plants of the Kaunas Botanical Garden of Vytautas Magnus University. Pressurized liquid extraction (PLE) was accomplished with ethanol (EtOH) and water (H_2O), while ultrasound-assisted extraction (UAE) with water. Antioxidant properties of extracts and solid residues were evaluated by the *in vitro* antioxidant capacity assays. $ABTS^{\cdot+}$ radical cation scavenging, CUPRAC - CUPric reducing antioxidant capacity, and oxygen radical absorbance capacity (ORAC) was expressed in Trolox (synthetic antioxidant) equivalents (TE), while total phenol content (TPC) was determined by the *Folin-Ciocalteu* method and expressed in gallic acid equivalents (GAE).

The study underscores the noteworthy antioxidant potential within leaf extracts of *D. caucasica* and *D. nipponica*, particularly when derived through diverse extraction methods. In contrast, root extracts did not exhibit the same heightened antioxidant activity. Total phenolic content (TPC) values of *D. caucasica* and *D. nipponica* leaves extracts, obtained through different methods, showcased a range of 205-240 and 219-253 mg gallic acid equivalents (GAE) per gram, respectively, with no statistically significant distinctions between extraction techniques. In the $ABTS^{\cdot+}$ radical cation scavenging assay, the *D. caucasica* extract demonstrated superior antioxidant capacity (836-866 mg Trolox equivalents (TE)/g) compared to *D. nipponica* (681-686 mg TE/g), although distinctions among extraction methods were not evident. The antioxidant capacity determined by ORAC revealed that *D. nipponica* extract obtained by UAE had two times higher antioxidant activity compared with PLE extracts (ethanol or water). The opposite trend was found in *D. caucasica* PLE-EtOH extracts. PLE-EtOH and PLE-H_2O recovered the majority of polar polyphenolic antioxidants. PLE-H_2O extracts were remarkably weaker antioxidants than PLE-EtOH extracts; however, due to the higher yields, EtOH recovered the major part of antioxidants as it was calculated for the whole plant DW. For instance, TPC in the residue after UAE was 4-7-fold lower than in the initial plant material and 12-21 fold lower when in PLE residues calculated for both plants. This data proves the efficiency of the applied extraction methods, especially of PLE. The findings suggest that both *D. nipponica* and *D. caucasica* extracts have diverse bioactive compounds, contributing to their antioxidant activity. These results propose potential applications in the development of nutraceuticals and functional foods, emphasizing the medicinal and health-promoting attributes of these plant extracts. Further research could delve into isolating and characterizing specific bioactive compounds to better understand their potential benefits.

Keywords: *Dioscorea* spp, pressurized liquid extraction, antioxidant capacity

ELEVATING BLACK CURRANT POMACE FROM WASTE TO WEALTH: A BIOREFINERY APPROACH

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ABSTACT

The growing demand for food supplements, cosmetics, and natural products presents an opportunity to utilize biorefining processes for the extraction of valuable natural compounds from various biowastes and byproducts of agricultural and food processing. These processes offer an environmentally friendly approach to resource recovery, enabling cost savings and potential profit generation while reducing environmental impact. Black currants are among the most extensively processed berries in Lithuania, and their resulting byproducts are often treated as waste. These studies aim to mechanically separate black currant pomace, investigate its chemical composition, and explore the potential of using bioactive compounds as high-value additives. The raw material was mechanically separated into two distinct fractions, namely the skins/residual pulp and seeds. Proximate nutritional composition, total phenolic compound, and anthocyanins were determined for each fraction. The supercritical CO_2 extraction ($scCO_2E$) was carried out at 60 °C and 45 MPa during 120 min. The results showed that the highest yield of lipids in the seed fraction was 15.66 % and 18.29 % by $scCO_2E$ and Soxhlet-hexane, respectively. Also, this fraction has a relatively high amount of protein 16.77% and dietary fiber 51.84%. In the meantime, the peel has a high content of carbohydrate - 77.80%, with a significant portion being dietary fiber at 43.46%, while the rest consists of fermentable sugars, namely 8.92 g/100g of glucose and 10.76 g/100g of fructose. The red colour of the peel extracts is due to the presence of anthocyanins, and a concentration of 25.65 mg GAE/g was detected in the total phenolic compounds assay with Folin-Ciocalteu reagent. Depending on the composition of the different fractions, seeds boast high fiber and protein content, making them ideal additives in food products while the oil fraction can be used in the food supplement and cosmetics industries. Meanwhile, the anthocyanins and phenolic compounds contained in the peel can be used in food and supplement production as a source of antioxidants or as a colour additive. The sugars contained in the fruit can also be biotransformed by fermentation into several useful reaction products such as organic acids, alcohols, etc.

Keywords: black currant pomace; biorefinery; supercritical CO_2 extraction; zero waste.

ANTIOXIDANT PROPERTIES OF DIFFERENT LETTUCE VARIETIES CULTIVATED IN A GREENHOUSE AND THEIR RESISTANCE TO *BOTRYTIS CINEREA*

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ABSTRACT

Nowadays requirements for safe and healthy food production are quite high. It is known that lettuce is one of the most favourite leafy vegetables all over the world because of its universal usage by meat lovers and vegetarians. The nutritional value of crispy and fresh lettuce consists of lots of vitamins, fibres, antioxidants, and minerals. Unfortunately, widely used fungicides not only leave traces on short vegetation lettuce but also increase the resistance to gray mold pathogen. Important to realize that harvest, presence, taste, and resistance against fungal diseases begin from the right selection of lettuce variety.

The research aimed to compare the antioxidative properties of different lettuce varieties after inoculation with *B. cinerea*. The experiment took place in the greenhouse with artificial lighting, using high-pressure sodium (HPS) lamps for a 16-h photoperiod. The photosynthetic flux density (PPFD) was maintained at approximately 200 µmol m^{-2} s^{-1}, and the day/night temperature was set at 23 ± 2/16 ± 2 °C with a relative humidity of 85 ± 10%. The PPFD of solar radiation was 20–80 µmol m^{-2} s^{-1} in November. Green-leaf var. May Queen and red-leaf var. Maiko lettuce were inoculated with the 7-days old *Botrytis cinerea* mycelium. Biochemical analyses were conducted from lyophilized leaves after a 5-days experiment period. Results revealed that red-leaf lettuce exhibited higher ABTS (2,20-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid)) and Fe^{2+} reducing antioxidant power assay (FRAP) values compared to green-leaf lettuce, regardless of inoculation. Additionally, the free radical scavenging activity (DPPH) was significantly higher in non-inoculated (318.2534 µmol g^{-1}) and inoculated (298.7633 µmol g^{-1}) red-leaf lettuce than green-leaf ones (190.1198 and 201.0966 µmol g^{-1}). Gray mold infection maintained the increase on green-leaf lettuce during experiment. Meanwhile, the infection on red-leaf lettuce tended to decline from 3 days post inoculation (DPI) till 5 DPI. Contrary, total phenolic compounds (TPC) of green-leaf lettuce was slightly higher than red-leaf despite inoculation or not but further work need to be done.

Keywords: gray mold, artificial infection, leafy vegetables, lighting, plant protection

ANALYSIS OF BIOTECHNOLOGICALLY AND PHYSICALLY TREATED BEE-COLLECTED POLLEN

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ABSTRACT

Bee pollen is a natural product made by bees (*Apis mellifera*) that people use to improve their health and well-being. Pollen itself contains a plethora of nutrients, minerals, phenolic compounds, and more. However, a significant challenge with pollen lies in its specific wall called exine. This wall makes pollen sturdy, elastic, and chemically resistant, causing humans to digest only a small fraction of consumed bee pollen.

To enhance the bioavailability of bee pollen, various treatment methods have been researched over the years. To our knowledge, there has been no research to determine the most optimal bee pollen treatment method. The aim of this study was to identify the most effective bee pollen treatment methods and analyze how they vary depending on the botanical origin of the bee pollen.

A bee pollen sample was subjected to 4 optimal treatment methods: fermentation with a mix of tibico and kombucha (1:1), fermentation with lactic acid bacteria (*Bifidobacterium infantis*), ultrasonication and a combination of enzymatic hydrolysis with ultrasonication. Changes in phenolic compounds and flavonoids were evaluated before and after treatment using spectrophotometric methods.

The optimal treatment methods were then applied to four different bee pollen samples from Trakai, Kedainiai, Panevezys and Varena regions of Lithuania. Quantitative analysis of total phenolic compounds, and flavonoids was performed using spectrophotometric methods.

Results indicated that all bee pollen treatment methods had a positive effect on the release of biologically valuable compounds. Phenolic compounds after treatment significantly ($p<0.05$) increased compared to pre-treated samples up to 121,1 %, and flavonoids up to 213,8 %. However, the effectiveness of release of biologically active compounds highly depended on the treatment method and the botanical origin of the pollen.

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Keywords: Bee pollen, spectrophotometry, phenolic compounds, fermentation

THE SEARCH FOR ANTIMICROBIAL AGENTS AGAINST PLANT PATHOGENIC BACTERIA

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ABSTRACT

Plant pathogenic bacteria play an important role in affecting plants and causing several kinds of diseases. The increasing use of chemical pesticides has been effective at controlling multiple diseases in major crops and other plants. However, immoderate use of synthetic chemicals has damaging effects on the environment and human health, which discourages pesticide application in the agriculture sector.

Paenibacillus species are known to produce a wide range of bioactive compounds (Li et al., 2021). Advances in sequencing technologies and genome mining have allowed us to identify potential novel bioactive compounds in silico, that could be beneficial in pest control. In this research, we used two endospore-forming cave strains of the genus Paenibacillus: 23TSA30-6 and 28ISP30-2, isolated from the deep oligotrophic Krubera-Voronja Cave (Lebedeva et al., 2021). Caves are known for their extreme conditions and as a result, there is a potential for the discovery of novel antimicrobials that are produced by bacteria living in such environment. This genus produces various small proteinaceous and peptidic structures, such as bacteriocins. These structures are classified as ribosomally synthesized and post-translationally modified (RiPPs), as well as lantibiotics and lantibiotic-like peptides.

Paenibacillus: 23TSA30-6 and 28ISP30-2 strains were tested against 8 plant pathogenic bacteria to see if there is any antibacterial activity and to determine produced antimicrobial compounds. Antimicrobial spot test and agar well diffusion method was used to evaluate the antimicrobial activity. Antibacterials compounds were salted-out with ammonium sulfate from cultures to determine if they had proteinaceous compounds. As a result, both strains had similar activity against Gram-negative plant pathogenic bacteria in a spot test. However, they differed in their activity against the Gram-positive test strain in antimicrobial activity when using the agar well diffusion method. In conclusion, our study showed that strains of the genus Paenibacillus have a high potential to produce metabolites against plant pathogenic bacteria and could be used as a pest control.

Keywords: Plant pathogenic bacteria, agriculture, bioactive compounds, *Paenibacillus*, bacteriocin, Krubera-Voronja Cave

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EXPLORING DIVERSITY, ANTAGONISTIC PROPERTIES AND PHOSPHATASE ACTIVITY OF ENDOPHYTIC BACTERIA IN *ARTEMISIA* SPP.

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ABSTRACT

Endophytic bacteria have great potential for sustainable agricultural practices, offering diverse benefits including pathogen suppression and nutrient enhancement within host plants. In this study, we investigated the diversity, antagonistic properties, and phosphatase activity of endophytic bacteria within different *Artemisia* species. Through isolation, identification, and characterization of bacterial strains from root, stem, and leaf tissues of four *Artemisia* plant species, a total of eighty-four endophytic bacterial isolates were obtained and subjected to molecular identification using a 16S rDNA gene sequence-based method. The isolated bacteria represented a diverse genus, with prominent genera including *Bacillus*, *Pseudomonas*, *Enterobacter*, and *Lysinibacillus*. Antagonistic assays revealed that 61 bacterial isolates exhibited inhibition against two pea root rot pathogens. Strains AR11 and VR24, isolated from *A. absinthium* and *A. vulgaris* roots respectively, displayed significant antagonistic activity. AR11 exhibited 90% inhibition against *Fusarium solani*, while VR24 showed 88% inhibition against *F. oxysporum*. Additionally, we evaluated the phosphatase activity of the isolated bacteria over 2, 7, and 10 days, revealing twenty-two strains demonstrating phosphate solubilization ability, with AR11 displaying the highest Phosphate Solubilization Index (2.93) after 10 days. The majority of effective strains belonged to the *Bacillus* genus, particularly those isolated from the root tissues of *Artemisia* spp. This research contributes to our understanding of the multifaceted roles played by endophytic bacteria in plant-microbe interactions, highlighting their potential for sustainable agriculture through pathogen control and nutrient availability enhancement.

Keywords: Endophytic bacteria, *Artemisia* spp., antagonistic activity, pea root rot pathogens, molecular identification, phosphate solubilization

IMPACT OF DRILLING TIME ON WINTER WHEAT PERFORMANCE: YIELD AND RELEVANT GRAIN QUALITY PARAMETERS

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ABSTRACT

The research investigates the influence of drilling time on wheat cultivation, specifically examining its impact on both yield and key grain quality parameters. By analyzing variations in drilling timing, the study aims to provide valuable insights into optimizing wheat production practices, contributing to enhanced agricultural efficiency and sustainable grain quality. A field trial investigating the impact of various sowing dates on winter wheat (*Triticum aestivum* L.) yield was conducted at the Institute of Agriculture field, Lithuanian Research Centre for Agriculture and Forestry, Lithuania, spanning the seasons from 2021 to 2023. The experiment involved three drilling times (early, optimal, and late) arranged in a randomized complete block design with a split-plot arrangement and four replications. All agronomic practices were uniformly applied to all treatments. Recorded observations encompassed hectoliter mass (kg hl^{-1}), 1000 grain weight (g), and grain yield (t ha^{-1}). Statistical analysis was performed using Duncan's multiple range test, with treatment means compared for variance differences at a 5% probability level. The data indicates a significant influence of sowing date on grain yield. In both 2021 and 2022, the highest grain yield (7.73 and 6.68 t ha^{-1}) was observed when the crop was sown at the late date, while early sowing resulted in the lowest yield (4.99 and 5.90 t ha^{-1}). However, in 2023, sowing time did not exert a significant impact on grain yield. The data about the 1000 grain weight reveals a noteworthy impact of sowing times on this parameter. In both 2021 and 2023, late sowing resulted in the highest 1000 grain weight, demonstrating significant differences compared to early sowing. Conversely, in 2022, there was a significant decrease in grain weight with delayed sowing. The early-sown crop exhibited significantly heavier grains (39.55 g) compared to the optimal and late-sown crops (38.49 g and 37.94 g, respectively). The results concerning hectoliter mass indicate a significant influence of sowing date on this parameter. In 2021, the hectoliter mass reached a significant maximum (75.12 kg hl^{-1}) when the crop was sown late, contrasting with the minimum mass (69.60 kg hl^{-1}) observed in the case of early sowing. However, no statistical differences were observed between sowing times in 2023. In conclusion, the research has systematically explored the impact of drilling time and sowing dates on winter wheat cultivation, focusing on grain yield, 1000 grain weight, and hectoliter mass. The findings underscore a substantial influence of sowing date on grain yield, with late sowing proving optimal in 2021 and 2022, while the year 2023 showed no significant impact. The 1000 grain weight was notably affected by sowing times, with late sowing yielding the highest weights in 2021 and 2023, but a significant decrease was observed in 2022. Additionally, hectoliter mass was significantly influenced by the sowing date in 2021, reaching a maximum with late sowing. These results provide valuable insights into refining wheat production practices, emphasizing the importance of optimizing sowing times for enhanced agricultural efficiency and sustainable grain quality. Further research and exploration may be warranted to better understand the underlying mechanisms and refine recommendations for wheat cultivation under varying environmental conditions.

Keywords: Harvest, Hectoliter mass, Sowing date, TGW, *Triticum aestivum*.

THE IMPACT OF DIVERSE TILLAGE AND CROP MANAGEMENT PRACTICES ON THE DYNAMICS OF WEED GROWING IN WINTER OILSEED RAPE

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ABSTRACT

Integrated weed management (IWM) is essential for sustaining the productivity of winter oilseed rape crops as well as environmental health. By combining various control strategies, farmers can achieve effective and sustainable weed management, ensuring the success of their crops in the long run. The field experiment on loam soil started in 2021 in Central Lithuania. The split-plot experiment comprised four replications. Three soil cultivation methods were employed: deep ploughing (22-24 cm), harrowing (8-10 cm), and direct drilling. The second factor was chosen from two: traditional and integrated weed management. In the conventional approach, herbicides were used, involving glyphosate application before or after drilling but before crop emergence. On the other hand, the integrated approach incorporated cover crops and implemented herbicide usage based on specific needs, excluding the use of glyphosate. The IWM involved field beans *Vicia faba* L. drilled together with winter oilseed rape in every second row. The objective was to assess appropriate IWM practices within sustainable tillage systems for the cultivation of winter oilseed rape. Based on three years of data, it can be observed that the rate and intensity of weed emergence varied each year. This was influenced by the fluctuating soil temperature and moisture and the prolonged absence of glyphosate, specifically in non-tillage treatments. It was observed that the number and species composition of weeds were very similar in the first two years. Still, in the third year, a significantly higher number of weeds was recorded in the no-till variants. The results of the third year showed that IWM usage resulted in nearly 25% fewer weeds than conventional weed control. It refers to and how cover crops influence weed suppression. When plants start covering the surface, natural competition arises, and about a month after sowing, winter oilseed rape begin to suppress weeds. However, the essential differences are when comparing tillage factors rather than integrated and traditional growing technology. Notably, differences in weed germination were more pronounced across tillage methods, with conventional tillage exhibiting nearly a 90% increase compared to harrowing variants and over a 150% surge in non-till conditions.

Keywords: tillage, weed management, soil, cover crops

BIOSYNTHESIS OF NOVEL BACTERIOCINS WITH ANTI-PHYTOPATHOGENIC ACTIVITY

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ABSTRACT

The Food and Agriculture Organisation of the United Nations estimates that 20-40 % of worldwide crop production is lost to pests, including bacteria, annually, making the need for novel concepts in agriculture crucial. Accordingly, these plant diseases caused by bacteria can reduce crop quality and yield [1]. For example, the bacterium making the strongest appearance on scientific and economic grounds is *Pseudomonas syringae*, which can cause bacterial speck of tomato [2]. However, current agricultural practices include the wide production and extensive use of chemicals known for their ability to cause negative health effects in humans and wildlife, and to degrade the natural environment. So, to solve this problem, it may be feasible to use bacteriocins, a heterogeneous group of ribosomally synthesized antimicrobial peptides that can kill closely related or a diverse range of bacteria species [3]. They can reduce the need for chemical pesticides and antibiotics, promoting environmentally friendly farming practices. Moreover, bacteriocins are much safer to use than some chemicals, and because they are specific to targets, they have no negative side effects.

The aim of this study was to identify bacteriocins that are secreted by microorganisms that have been isolated from the soil and may have an impact on phytopathogenic bacteria. A total of 63 isolates were isolated from the soil and screened in order to evaluate their antibacterial activity against 9 phytopathogenic bacteria strains, such as *P. syringae, Pectobacterium carotovorum*, *Xanthomonas vesicatoria*, etc. We successfully identified two bacteria strains: *Streptomyces* sp. AB3 and *Bacillus velezensis* DM1.10 that produce antibacterial substances. *B. velezensis* DM1.10 genome analysis revealed 14 gene clusters, 3 of which are associated with bacteriocin synthesis. 4 of 41 gene clusters identified by analysis in *Streptomyces* sp. AB3 genome are involved in the production of bacteriocins. One of the identified bacteriocin biosynthesis gene clusters encoded in *Streptomyces* sp. AB3 is lasso-type bacteriocin and in *B. velezensis* DM1.10 strain is an LCI-type bacteriocin. In this study, we describe bacteriocin gene cloning and heterologous biosynthesis of the lasso peptide and LCI-type bacteriocins in *Escherichia coli* cells and their antimicrobial activity evaluation against phytopathogenic bacteria.

Keywords: Bacillus; Streptomyces; heterologous expression; lasso peptide; LCI-type bacteriocin.

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EVALUATION OF *AEGOPODIUM PODAGRARIA* ANTIOXIDANT AND ANTIMICROBIAL ACTIVITY USING DIFFERENT EXTRACTION SOLVENTS

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ABSTRACT

Nowadays, there is a growing demand for natural compounds that can substitute chemical food preservatives in performing their functions. Plants synthesize a wide variety of phytocompounds that possess antioxidant or antimicrobial properties. Therefore, they have the potential to be used as natural preservatives to extend the shelf life of a food product or as antimicrobial agents to prevent spoilage microorganisms and provide antioxidant protection. A widely distributed plant, *Aegopodium podagraria*, is known to exhibit signs of preventing bacterial growth or having antioxidant properties, thus it can be utilized in the food industry, taking advantage of its possessing qualities. The aim of this study was to evaluate the antioxidant and antimicrobial properties of the plant *Aegopodium podagraria* using different extraction solvents: water, 50% ethanol, and olive oil. The determination of the concentration of phenolic compounds, flavonoids, and antioxidant activity was carried out by spectrophotometric methods, while the antimicrobial activity on five bacteria was determined by well diffusion method. Leaves, stems, and roots were used for the experiment, and the extracts were prepared by the incubation shaking maceration method. It was determined that the concentration of biologically active compounds and antioxidant or antimicrobial activity depended on the solvent used for the extraction. The highest concentration of phenolic compounds was determined in leaf and stem ethanolic extracts, ranging from 5,73 to 9,57 mg RE/g, while the highest concentration of flavonoids (3,25–3,87 mg RE/g) was determined in oil extracts. Root extracts demonstrated different results - the highest concentrations of phenolic compounds (5,99 mg RE/g), flavonoids (0,36 mg RE/g), and antiradical activity (2,16 mg RE/g) were all obtained using water as an extraction solvent. The correlation between antioxidant activity and the concentration of phenolic compounds was established. All the extracts demonstrated antimicrobial activity against different bacteria. Leaf extracts showed inhibitory effects on *Escherichia coli*, *Micrococcus luteus*, and *Staphylococcus aureus*, while root extracts were also effective against *Leuconostoc mesenteroides* and *Pseudomonas aeruginosa*. The demonstrated properties of the plant *Aegopodium podagraria* reveal its potential application in the food industry as an antioxidant and antimicrobial agent, which has the capability to inhibit the growth of undesirable microorganisms or contributes to overall food safety.

Keywords: *Aegopodium podagraria* L., plant extracts, antimicrobial activity, antioxidants, food safety

EFFECT OF SEED TREATMENT FUNGICIDES ON YIELD INCREASE AND ROOT ROT INTENSITY IN DIFFERENT WINTER WHEAT VARIETIES AND SOWING TIMES

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ABSTRACT

Population growth has substantially increased the demand for maximum yields. Farmers must therefore consider all possible measures to ensure high cereal production. Root rots caused by *Fusarium* spp. and *Microdochium* spp. are key limiting factors on forming productive crops in early growth stages. Apart from the selection of a more resistant variety and the timing of sowing, seed treatment fungicides are the main control measure for seed-borne and soil borne diseases in winter cereals. In this study, we compare the effect of different seed treatments and sowing times on diseases and yield in four varieties of winter wheat.

A field experiment in two different sowing times was carried out in growing season of 2022–2023 in Lithuania. Seeds of four selected varieties were treated with different seed treatment fungicides and were sown at optimal and late sowing time. Untreated seeds were sown in control plots. Root rots were evaluated in early spring, and yield was harvested when crops were fully ripe.

Weather conditions in winter 2022–2023 were quite favourable for pathogens causing root rots to infect and proliferate. Disease pressure in untreated control varied from 10.4 to 51.1 % in optimal time sown plots and from 23.7 to 57.5 % in later sown plots. In optimal time sown cv. ‘Patras’ seed treatment fungicides reduced disease severity by 60.5 % (from untreated control). The highest control on root rots in later sown winter wheat was recorded in cv. ‘Ada’ as severity decreased from 57.5 % average in untreated control to 34.9 % in treated plots. In the context of very high disease pressure, seed treatment resulted in significant yield increases in some varieties. The yield of the most infected late sown ‘Ada’ and ‘KWS Emil’ was twice higher in treated seed plots.

Keywords: Seed treatment, root rots, winter wheat.

UNLOCKING THE SECRETS OF *MANDRAGORA OFFICINARUM'S* PHYTOCHEMISTRY AND BIOACTIVITIES

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ABSTRACT

Mandragora officinarum L. is a type of species that belongs to the *Mandragora* plant genus in the nightshade (*Solanaceae*) family. Mandrake is a herbaceous, perennial plant and is native to the Mediterranean region. This plant has been widely used in ancient times regarding its healing and psychotropic properties. However, nowadays its use has notably decreased due to the presence of tropane alkaloids, which can lead to poisoning.

There aren't a lot of publications on *M. officinarum* chemical composition and bioactivities, and the majority of the previously performed studies were focusing on its alkaloids. The aim of this study was to fractionate several anatomical parts (fruits, leaves and roots) of this plant in to the lipophilic and higher polarity fractions by using consecutive extraction with supercritical CO_2 and pressurized liquids using the increasing polarity solvents and to evaluate the fatty acid composition and antioxidant potential of the fractions obtained. Firstly, proximate composition of *M. officinarum* fruits and roots was evaluated by using standard methods. After measuring the quantities of proteins, fats, crude fibers, minerals and moisture content, extraction with supercritical CO_2 was carried out. After the raw materials were defatted, pressurized liquid extraction was accomplished using different polarity solvents: acetone, ethanol, and water.

The highest amount of lipophilic fraction was collected from freeze-dried fruits of mandrake, and the highest amounts of polar extracts were collected as following: water extract - leaves collected in May, ethanolic extract - freeze-dried fruits, acetone extract - oven dried fruits. Additionally, the total amount of phenolic compounds and ABTS radical scavenging activity were also determined in the roots, fruits and leaves of this plant. The same assays were also carried out not only with dry raw materials but also with the obtained lipophilic and polar fractions.

Keywords: Mandragora officinarum, supercritical fluid extraction, pressurized liquid extraction, antioxidant capacity.

COMPARATIVE ANALYSIS OF ANTIOXIDANT POTENTIAL IN *DESMODIUM CANADENSE* ACROSS DIFFERENT GROWTH STAGES

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ABSTRACT

The evaluation of the antioxidant potential of *Desmodium canadense* marks a significant inquiry into the bioactive properties of this plant. *D.canadense*, commonly known as Canada tick-trefoil, has garnered attention for its diverse applications, including its potential role in human health and well-being. This investigation aims to unravel the extent of *Desmodium canadense's* antioxidant capabilities, exploring how these properties may vary across distinct growing stages viz, intensive growing, botanization, beginning of flowering, massive flowering, and end of blooming. The lipophilic fraction was extracted from dried *D. Canadense* samples using supercritical carbon dioxide extraction (SFE-CO_2) and yield was calculated into g/100g of dried sample. The antioxidant capacity of solid plant material was assessed both before and after SFE-CO_2 using the QUENCHER method estimating total phenolic contents (TPC) and Trolox equivalent antioxidant capacity (TEAC) in scavenging $ABTS^{+\cdot}$. After that, pressurized liquid extractions (PLE) were applied to obtain antioxidant-rich higher polarity extracts employing increasing polarity solvents, such as acetone, ethanol, and water under optimal conditions of temperature and pressure. Sequential extractions using solvents of escalating polarity facilitate the isolation of varying quantities of antioxidants. The highest lipophilic fraction by supercritical CO_2 was 1.40 g/100 g at the massive flowering stage, TPC and $ABTS^{+\cdot}$ values were 84.01 mg GAE/g, 257.78 mg TE/g, respectively before and 91.88 mg GAE/g, 338.98 mg TE/g respectively after lipophilic extraction. The lowest fatty acids were contained at the last stage of blooming (0.96g/100g). In general, ethanol extracts of PLE exhibited higher antioxidant capacity values at every growth stage in comparison to extracts with other polarity solvents. While in comparison to growth stages, higher antioxidant values were given at massive flowering and botanization stages. Hence the best times to collect *Desmodium canadense* are during massive flowering and botanization phases. At these stages of growth, the herbs likely have higher concentrations of desirable compounds, such as antioxidants or active ingredients, making them more suitable for various applications such as herbal medicine or natural product extraction. By harvesting during these phases, one can potentially maximize the yield and quality of the raw material obtained from the showy tick trefoil plants.

By systematically evaluating the antioxidant potential of *Desmodium canadense*, this study aims to provide valuable insights that may have implications for human health and ecosystem resilience.

Keywords: *Desmodium canadense*; antioxidant capacity; supercritical carbon dioxide extraction, pressurized-liquid extraction

APPLICATION OF PHYSICAL METHODS IN THE BIOTECHNOLOGICAL PROCESSING OF PLANT BY-PRODUCTS

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ABSTRACT

The rational utilization of plant raw materials, especially their by-products, is one of the most relevant objectives in sustainable plant processing technologies. The consumption habits of society are changing, which causes the growing emphasis on balancing the ratio of plant-based and animal-based food in the human diet, giving priority to plant-based food. Therefore, it is relevant to develop processing technologies for plant raw materials, especially their by-products, to rationally use various bioactive compounds and phytochemicals for the production of functional food products. A practical issue in implementing these ideas is the macrostructure of plant raw materials and their by-products (e.g., pomace), where the efficiency of bioprocessing, such as fermentation with lactic acid bacteria (LAB), is low and economically not viable. Therefore, the search for effective methods of changing the macrostructure of plant raw materials is relevant.

Berry pomace, including raspberry pomace, is a by-product of the berry processing industry, which has a limited application due to the risk of microbiological spoilage and unfavorable macrostructure for fermentation. Additionally, raspberry pomace is rich in phytochemicals that exhibit antimicrobial and antioxidant properties, contributing to the microbiological stability and functionality of the final product. Conventional extraction methods of these compounds have certain limitations in terms of time, energy, and solvent requirements. In contrast to conventional extraction methods, ultrasound operates at low temperatures, requiring less energy, time, and solvent. Ultrasound enhances the biological availability of nutrients for microorganisms without altering the quality of the raw material. Additionally, the disruption of cell walls causes the release of biologically active compounds. However, the parameters of ultrasound, such as frequency, power, temperature and time need to be optimized for different raw materials. Therefore, the aim of this study is to optimize the extraction of biologically active compounds from raspberry pomace before fermentation using physical methods and selecting optimal parameters.

Low frequency (37 kHz) ultrasound at different intensities (40, 70, 100, 120 %) was applied to fresh raspberry pomace at 35 °C for 15, 30, and 45 min. The efficiency of ultrasound pretreatment was characterized by the increase in total concentration of phenolic compounds and monomeric anthocyanins, and antioxidant activity of raspberry pomace. Optimal ultrasound parameters were selected, and pretreated raspberry pomace was used for the production of fermented beverages using symbiotic culture and LAB. The usage of pretreated raspberry pomace resulted in higher concentrations of phenolic compounds, monomeric anthocyanins and antioxidant activity in the fermented beverages, compared to control. Both ultrasound pretreated and fresh raspberry pomace resulted in more microbiollogically stable beverages compared to the control. These findings suggest that the by-product of the berry processing industry may be a promising source of phytochemicals that could be used for the production of probiotic fermented beverages.

Keywords: ultrasound, plant by-products, phytochemicals, lactic acid bacteria, fermentation.

COMPARING BIOCHEMICAL PROPERTIES OF SEA BUCKTHORN (*HIPPOPHAE RHAMNOIDES* L.) LEAVES: ENZYME-ASSISTED EXTRACTION VS. SOLID-LIQUID EXTRACTION

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ABSTRACT

In recent years, there has been a growing interest in exploring the phytochemical composition and antioxidant potential of natural sources. The leaves of the sea buckthorn plant, scientifically known as *Hippophae rhamnoides* L., contain significant bioactive compounds that may offer natural healing advantages for various purposes. While there are different methods to recover bioactive fractions from by-products, there is limited information on enzyme-assisted extraction (EAE) of sea buckthorn leaves. The aim of this study was to compare the biochemical properties and antioxidant activity of sea buckthorn leaves (SBL) extracts using EAE and conventional solid-liquid extraction (SLE) techniques. The antioxidant potential of SBL extracts was tested using ABTS and FRAP assays, and the total phenolic content was determined with the Folin-Ciocalteu method. Sugar and organic acids profiles were evaluated by high-performance liquid chromatography (HPLC) analysis. The total protein content was obtained by Lowry assay. Moreover, scanning electron microscopy (SEM) was used to observe changes in the cell wall morphology of SBL residue after EAE. Three different EAE extractions were carried out under optimal conditions (3:15 h of extraction, temperature 45 °C, pH: 4.9, and 1% enzyme (v/w of dry leaves). The extractions were performed using Viscozyme L, Cellulase enzymes, and control without enzyme. The yields obtained were 26.4 g/100 g DW, 14.9 g/100 g DW, and 17.8 g/100 g DW, respectively. Additionally, an SBL extract obtained using solvent liquid extraction yielded 18.1 g/100 g DW. The SBL extract with Cellulase enzyme had the highest amount of protein at 24.23 mg/ml. However, the results indicated that SBL extract with Viscozyme L enzyme was the most active in all *in vitro* assays. SEM images confirmed the successful cleavage and hydrolysis of hydrolytic enzymes. In conclusion, EAE provides a viable alternative to traditional extraction methods for obtaining valuable bioactive compounds from SBL, which has implications for the food, pharmaceutical, and cosmetic industries.

Keywords: sea buckthorn leaves; *Hippophae rhamnoides* L.; enzyme-assisted extraction; conventional solid-liquid extraction; antioxidant activity

MICROENCAPSULATION PROPERTIES OF MODEL FLAVOURS SPRAY-DRIED INTO MODIFIED STARCHES

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ABSTRACT

The effect of eight different modified food starch carrier materials on the flavour retention of model aroma oil during spray drying and storage were evaluated. Five aroma components eucalyptol, benzaldehyde, limonene, linalool, and geranyl acetate were combined into one model mixture at equal parts by weight and used as core material. The emulsification and encapsulation efficiencies were evaluated and the changes in the composition of flavours after processing were analysed by GC-FID and GC-MS. The emulsification efficiency of model aroma oil in the liquid emulsions was up to 99 %. The encapsulation efficiency of model oil was also higher for all OSA-modified starches matrices (82-94 %) compared to hydrolysed starches (57-71 %). The content of oil remaining on the surface of encapsulated powder did not exceed 2 %. Our results obtained are in agreement that hydrolysed starches lack lipophilic characteristics and, consequently, do not retain well water insoluble aromas. The composition of pure, emulsified and encapsulated in different modified starch matrices model aroma oil was quite similar, however some changes in the percentages of some individual compounds were observed. Larger differences in the composition of surface oils from various encapsulation products were obtained.

The release rate of flavours from different microencapsulated products was determined by dynamic headspace method (DHS-GC-FID). The recovery of model oil volatiles that were released into the headspace from the spray dried encapsulated products were collected on Tenax traps via timed intervals of nitrogen purge and further analysed by GC-FID. The amounts of volatiles released into headspace were different between various products; aroma components were released at different rates by each of encapsulated products. OSA-starches were more effective to retain and protect flavours and release rate was slower; both hydrolysed starches showed the poorest retention of model aroma oil and the leakage of volatiles into the headspace from these matrices were faster.

Storage stability evaluation, i.e. the formation of oxidation compounds, was measured as a function of time for determining the protective properties of different coatings during storage. Monitoring was carried at room and 60 °C temperatures in the absence of light for 20 weeks period; prepared samples were analysed by GC-MS. The oxidation proceeded faster at 60 °C of storage compared than at room temperature and higher amounts of oxidation products were calculated. Limonene and linalool losses were primarily due to oxidation; the oxidation products, such as, limonene and linalool oxide isomers were formed. For example, the oxidation products of most volatile monoterpene limonene, *trans*- and *cis*-limonene oxides, in pure model aroma oil were detected after 1 week of storage and by week 4 in encapsulated powdered products, however the concentrations were significantly lower compared to that in pure non-encapsulated model oil. As it was expected, samples stored at room temperature were more resistant to oxidation compared to that of 60 °C, however oxidation rate of encapsulated products was significantly slower than oxidation of pure model aroma oil. OSA-starch gave highest protection to limonene and linalool by limiting its oxidation, up to 42 times difference in oxidation between non-encapsulated and microencapsulated model aroma oil.

Keywords: Model aroma oil; Microencapsulation; Spray drying; Aroma retention; Flavour release; Storage stability

FERMENTATION OF *CHLORELLA VULGARIS* TOWARDS FOOD AND NUTRACEUTICAL APPLICATIONS: A FEASIBILITY STUDY

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ABSTRACT

The worldwide transformation in food manufacturing, health and nutrition, environmental and social sustainability efforts, and economic progress have lately increased interest in marine sources, especially microalgae. Algae were initially considered as potential substrates for second-generation biofuels. However, studies indicate that microalgae can be excellent sources of protein and bioactive substances that can be used for food, nutraceutical, pharmaceutical, and cosmetic applications. Fermentation is an ancient preservation technique to improve foods' stability and organoleptic properties. Moreover, this process can potentially enhance the nutritional value of the final product(s) and enable the release of bioactive substances or the biotransformation of the substrate into added-value products. For these reasons, recent reviews indicate that microalgal fermentation for applications other than biofuels may be the seed for a new fermentation industry. Few studies have demonstrated the feasibility of utilizing *Arthrospira sp.* as a fermentation substrate for food applications and highlighted the enhanced bioactive properties of the final products. However, there is a lack of knowledge on the feasibility and effect of fermentation on other microalgal species. Towards this, this study aimed to evaluate *Chlorella vulgaris* as a potential substrate for fermentation by lactic acid bacteria (LAB) and other fermenting microorganisms. In the first step, the chemical composition of Chlorella biomass was analyzed. The biomass had 46.34% protein, 5.78% ash, 5.18% moisture, 3.01% lipid, and 39.69% carbohydrate. The following step evaluated different bacterial strains and their effect on physicochemical parameters (i.e., pH, vitamin, organic acid content) during fermentation. Samples were withdrawn at different intervals (0, 8, 24, 48, and 72 hours). The maximum growth (8.71 logs CFU/ml) was observed with *L. plantarum* after 48h, while strains showed a similar acidification rate, with the lowest pH value (~4.5) after 72 hours of fermentation. HPLC-UV assessed the organic acid production during fermentation and, as expected, indicated lactic acid and acetic acid as the major metabolic products. Moreover, HPLC-MS/MS characterized vitamin and free amino acid (FAA) changes during fermentation, revealing the increased FAA content and water-soluble vitamin changes and fortification during fermentation. Lastly, the *in vitro* antioxidant capacity changes at different time points were monitored with the total phenolic content, DPPH, ABTS, and CUPRAC assays. Overall, this study reveals the feasibility of *Chlorella vulgaris* and LAB for producing fermented algal formulations towards various applications. Further studies are required to screen these extracts' potential bioactive properties and safety.

Keywords: fermentation, bioactive compounds, microalgae, chlorella vulgaris, antioxidant capacity.

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3.3. Climate change, Plant Genetics and Breeding

SCREENING OF WHEAT RESISTANCE TO FHB USING DIFFERENT KINDS OF INOCULATION

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ABSTRACT

Fusarium head blight (FHB) is a destructive fungal disease in wheat caused by the *Fusarium spp*. complex. It results in reduced end-use quality as well as the mycotoxins accumulation in the grains. The development of resistant cultivars is the most effective strategy to control the disease. However, breeding for resistance is hindered by the multigenic nature of resistance, the availability of adapted resistance germplasm, and the reproducibility of phenotyping. The purpose of this study was to investigate the set of 335 spring wheat genotypes, which consists of modern wheat cultivars, breeding lines, and exotic germplasm for resistance to FHB. To ensure the accuracy of screening, a range of experiments were performed under controlled and field conditions using different inoculation methods. For this purpose, six different trials were conducted using various inoculation methods (i.e., spray, spawn, and precise). Applying a combined analysis of Best Linear Unbiased Estimators (BLUEs) values, genotypes exhibiting consistent resistance to both types I and II to FHB were identified.

Keywords: Fusarium head blight (FHB), Wheat, BLUES.

SORGHUM CULTIVATION IN TEMPERATE CLIMATE AND ITS NUTRITIONAL POTENTIAL

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ABSTRACT

The research on sorghum in Poland began with cultivars harvested for biomass production, as they were characterized by rapid growth, high straw yield and did not produce generative organs in the soil and climatic conditions of Poland. However, intensive breeding work provided to study the possibilities of cultivating varieties that give fully mature seeds every year in temperate climate conditions. Five prospective varieties of sorghum were selected for field research. The average grain yield was 3-8 t/ha at 15% moisture. It indicates that with the ongoing climate change, it is possible to grow sorghum above 50 degrees north latitude. In addition, the research carried out so far in Poland has shown the high nutritional potential of this plant and the richness of active substances contained in sorghum grain from domestic crops. It has been shown that the tested material is a rich source of bioactive compounds with antioxidant properties. Among the carotenoids, lutein and zeaxanthin were the most found, and in the case of sterols, sorghum grain contained the most beta-sitosterol. Moreover, catechin is a flavonoid present in the highest concentration in the analyzed grain samples. Among the phenolic acids, the highest content in sorghum seeds was found for ferulic, p-coumaric and protocatechuic acids. Currently, research on the possibility of sorghum cultivation in Poland and its nutritional potential has been supported by the Ministry of Agriculture and Rural Development as part of research on biological progress in plant production.

Keywords: sorghum bicolor, seeds, climate change, bioactive compounds, antioxidant properties

PRELIMINARY FINDINGS FROM THE MORPHOLOGICAL ASSESSMENT OF NORWAY SPRUCE GENE CONSERVATION UNITS (GCU) IN LITHUANIA

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ABSTRACT

The Norway spruce covers 21.1% of the total forest area in Lithuania, holding significant economic and ecological importance. However, the year 2023 posed considerable challenges for Norway spruce forests across Europe, including Lithuania, due to widespread bark beetle attacks. The changing environmental and climate conditions are amplifying the intensity and frequency of pest and disease outbreaks in Lithuanian forests. Therefore, preserving genetic and morphological variation in forest ecosystems becomes crucial for their adaptation to climate change. Populations with lower genetic diversity may be more susceptible to diseases and pests, potentially leading to reduced productivity or forest mortality. Understanding the genetic diversity and structure of Norway spruce populations (forest genetic resources/gene conservation units of Norway spruce) in Lithuania through DNA markers is essential to enhance their resilience and adaptation to ongoing environmental changes. Thus, the combination of genetic knowledge and morphological assessment can offer insights into the adaptation mechanisms of Norway spruce to a changing environment. The primary objective of PhD project is to investigate the genetic structure and diversity of Norway spruce populations in Lithuania, employing various DNA markers, including nuclear, chloroplast, and mitochondrial DNA analysis. This investigation will be complemented by a morphological assessment, considering factors such as stand health, branch angle, stem straightness, spike knot, etc. First results of the PhD project's morphological assessment will be presented.

Keywords: *Picea abies* (L.) H. Karg., morphology, Forest Genetic Resources, FGR

BREEDING AND REINTRODUCTION OF ENDANGERED *BUBO BUBO* SPECIES IN LITHUANIA

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ABSTRACT

The Eurasian eagle-owl (*Bubo bubo*) is a protected species included in the Red Data Book of Lithuania. Its status is listed as endangered and has a very high risk of extinction in the wild. *B. bubo* is native to Eurasia. The highest threats for *B. bubo* populations are disturbance of nesting birds during the breeding season, destruction of clutches by predators, and deforestation. This species is also affected by climate change and fluctuations in the abundance of prey. In Lithuania, the survival of very small and fragmented *B. bubo* populations mainly depends on individuals immigrating from neighbouring countries. The objective of the research was to increase the population of *B. bubo* in Lithuania by carrying out breeding, adaptation, release and tracking activity of individuals. During the research project, *B. bubo* breeding methodology was created and successfully applied. *B. bubo* juveniles were trained to gain hunting skills essential for survival in the wild. They were released to the forest from adaptation enclosures using the soft release method. Birds were able to choose the most convenient time for them to fly out of the enclosure. Before release, tracking transmitters were applied to the birds which sent data about the exact location of individuals. This data allowed us to see when juveniles were the most active, make predictions about their hunting success and further survival in the wild.

Keywords: *Bubo bubo*, predatory birds, endangered species, breeding, hunting instincts

UNRAVELING THE GENE EXPRESSION DYNAMICS OF WINTER WHEAT DURING COLD ACCLIMATION, DEACCLIMATION, AND REACCLIMATION

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ABSTRACT

Freezing tolerance in winter wheat is achieved through the process of cold acclimation (CA). CA is induced by low positive temperatures and takes approximately 7 weeks. Nevertheless, global climate change is hindering CA via elevated temperatures and increased cloudiness in autumn, leading to insufficient freezing tolerance. Moreover, the significant temperature fluctuations in winter induce deacclimation (DEA), which leads to premature loss of freezing tolerance. Therefore, the crops that possess the ability to reacclimate (REA) are more likely to survive sudden cold spells. Currently, the processes of DEA and REA are still poorly understood, and more research is required to improve climate resilience in winter wheat. Two winter wheat genotypes with previously established contrasting levels of freezing tolerance were chosen for this study. Three-leaf stage winter wheat seedlings were transferred to a phytotron and exposed to CA at 2 °C for 7 weeks, DEA at 10 °C for 1 week, and REA at 2 °C for 2 weeks. Crown region and leaf tissue samples were collected after 7 weeks of CA, 24 hours of DEA, 1 week of DEA, 24 hours of REA, and 2 weeks of REA. For each sampling point the crown region and leaf tissue samples were taken in 3 biological replicates and total RNA was extracted for RNA sequencing. Raw RNA sequencing reads were processed and mapped on spring wheat "Chinese Spring" IWGSC RefSeq v2.1 transcriptome. Differential gene expression analyses revealed significant changes in gene expression throughout CA, DEA, and REA in crown region and leaf tissues. Subsequent gene ontology enrichment analyses elucidated the contrasting patterns of gene expression in freezing-tolerant and freezing-susceptible genotypes. The findings of this study provide novel insights into the DEA and REA processes and contribute valuable knowledge towards the enhancement of future crops under global climate change.

Keywords: abiotic stress, climate change, freezing tolerance, *Triticum aestivum* L.

GENETIC DIVERSITY OF *QUERCUS ROBUR* (L.) OLD GROWTH TREES IN LITHUANIA BASED ON DNA MARKERS

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ABSTRACT

Pedunculate oak (*Quercus robur* L.) forests cover only 2.3% of Lithuania's total forests, but the conditions (commercial value and viability) of Lithuania's oak forests is not sustainable. The aim of the study was to investigate the genetic value of Lithuanian *Quercus robur* L. old-growth trees based on chloroplast DNA (cpDNA) and nuclear DNA (nDNA) markers. We used 3 chloroplast microsatellite (cpSSR) markers to identify the evolutionary lineages of 347 natural-origin old-growth *Quercus robur* trees - the nature monuments and 14 nuclear microsatellite (nSSR) markers to investigate their genetic diversity and structure. Also, morphotype, skeletal branch angle and bark type were determined for each 347 old-growth *Quercus robur* trees in Lithuania.

The analysis of nuclear DNA markers of *Quercus robur* old-growth trees showed that there are two main regional genetic groups of autochthonous populations in Lithuania: in north-eastern Lithuania and the rest of Lithuania.

It was found 5 evolutionary lineages of Lithuanian *Quercus robur* old-growth trees that migrate from Eastern and Western Italy, Germany, Balkan and Spain glacial refuge zones. We found that the geographical distribution of haplotypic evolutionary lineages in the Lithuanian territory is not random - the most common haplotypes in the country are the Balkan lineage haplotype H5_BALK (44% of trees) and the German haplotype H4_DE (33% of trees), both of which are distributed in all parts of the country. The German haplotype H4_DE is particularly common in the western part of Lithuania (Samogitia region) and rarer in the northern-eastern part of Lithuania. The Eastern Italian H6_EAST_IT haplotype is found exclusively in eastern Lithuania. The study shows that there are largely related *Quercus robur* stem quality and bark morphotypic characteristics specific to their evolutionary lineage, as well as a high genetic diversity. The study shows that German haplotype H4_DE has commercially the best single-stemmed morphotype, especially in central Lithuania (about 50% of trees.

Keywords: pedunculate oak, genetic diversity, haplotypes, microsatellites, chloroplast DNA, nuclear DNA, evolutionary lineages, monuments trees.

PARADIGM OF ECOLOGICAL FLOW AND ITS APPLICATION PERSPECTIVE FOR LITHUANIAN RIVERS

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ABSTRACT

European Union (EU) water resources continue to deteriorate regardless of their vital role to societal and ecological well-being. Disturbance of natural flow patterns is one of the main drivers of deteriorating river health that is hindering the achievement of the good ecological status, which is the goal of the EU Water Framework Directive (WFD). Natural flow regime, characterized by certain natural variability and seasonality, is essential for supporting healthy fluvial ecosystems through preservation of habitats. However, flow regimes are altered by multiple anthropogenic activities, such as the building of barriers, hydropower operation and abstraction of water, overall leading to deterioration in ecosystem health. To tackle this issue, the EU sets out guidance in WFD and Birds and Habitats directives to halt loss of biodiversity and sustain healthy ecosystems and habitats by bringing in the concept of ecological flows (E-flows). In the WFD, ecological flow is defined as "an hydrological regime consistent with the achievement of the environmental objectives of the WFD in natural surface water bodies as mentioned in Article 4(1)". WFD suggests that E-flows should be sustained by means of including it into national frameworks and national River Basin Management Plans (RBMPs) to control impacts of anthropogenic activities on rivers and assist in meeting environmental objectives of EU legislation. However, the definition of E-flows varies across EU Member States (MS), with one unifying factor, namely that E-flows are meant to sustain biodiversity and ecological functions of water bodies. In Lithuania, E-flow has no legal definition and it is not involved in national legislation. Instead, environmental flow, defined as minimum water needed to sustain ecosystem health, currently exists as a legally binding measure. However, it has been recognized by Lithuanian scientists as generally unfit for adequate protection of ecosystems and for reaching WFD goals related to "good ecological status" due to lack of ties to biological indicators of ecosystem health. In this study, a systematic literature review was conducted to review cases of various EU countries: to describe and compare the ways that E-flows are defined, the methods used to estimate them, the manner in which E-flows are applied across the selected cases. The review depicts the variation of E-flows among selected cases of the EU MS legislation and methodological aspects. Further, their potential application in Lithuanian rivers is estimated. This assessment may further aid Lithuanian national legislation and regulation in order to state the measures necessary to meet environmental objectives in relation to the hydrological regime of rivers, as set out in the EU nature directives. Additional assessments are needed to evaluate the impacts of climate change on future ecological flows which is likely to bring challenges to sustainable water management of Lithuanian rivers.

Keywords: ecological flows, Water Framework Directive, hydrological regime, fluvial ecosystems, Lithuanian rivers

THE EFFECT OF BIOSURFACTANT ON SOIL NUTRIENT LEVELS DURING LEGUME-BASED PHYTOREMEDIATION OF PETROLEUM HYDROCARBONS-CONTAMINATED SOIL

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ABSTRACT

Fossil fuels contaminate the soil with petroleum hydrocarbons. To aid phytoremediation, biosurfactants are a promising additive. Post-decontamination, soil should be reusable sustainably. Biological soil treatment should restore and increase its properties. The aim of this study was to evaluate the impact of biosurfactant on changes in nutrient levels during phytoremediation of diesel-contaminated soil by three species of legumes (*M. albus*, *M. sativa* and *L. corniculatus*). Legumes were grown in soil containing diesel (4000-6000 mg kg^{-1}) for 90 days, and changes in soil nutrient amount and plant growth were measured. The concentration of nitrates, a significant soil nutrient, decreased significantly during soil phytoremediation because nitrates are used during plant growth and the decomposition of petroleum hydrocarbons by microorganisms. However, compared to non-planted treatments, the loss in nitrate concentration was less significant. Soil NH_4^+ concentrations were similar to the initial levels in most treatments but tended to be higher with increased diesel concentration and the use of biosurfactant. The addition of biosurfactant was the main factor responsible for the increased inorganic phosphorus concentration in both planted and unplanted soil. *M. sativa* and *L. corniculatus* produced more phenols in all treatments except control, while *M. albus* exhibited the opposite trend. In treatments without plants, there was a decrease in water-soluble phenols compared to the baseline. The addition of biosurfactant also resulted in a significant increase in soluble phenols, possibly due to the composition of the used biosurfactant, which contains water-soluble phenols.

Keywords: *Legumes*; nutrients; phytoremediation, biosurfactant

VARIABILITY IN SEED CHARACTERISTICS AMONG WILD ECOTYPES OF *LOTUS CORNICULATUS* L. IN LITHUANIA

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ABSTRACT

Legume crops are increasingly recognized as pivotal for enhancing the sustainability of European farming systems. However, many legumes, particularly minor species, have been overlooked in the EU, limiting their research and utilization. The once-neglected bird's foot trefoil (*Lotus corniculatus* L.) is now rediscovered as a valuable resource for sustainable agriculture in Europe. Due to various factors, minor legumes are gaining significance both locally and globally. Bird's foot trefoil, a moderately long-lived perennial forage legume, has garnered renewed interest for its role in improving sustainability in low-input livestock systems and maintaining biodiversity on farms. Incorporating minor legume species into farming systems enhances ecosystem resilience, soil fertility, and biodiversity, while reducing reliance on synthetic fertilizers. Bird's foot trefoil exhibits adaptation to diverse environmental conditions, making it suitable for poor soils and fluctuating climates. It provides highly nutritious forage without causing bloating, potentially reducing methane emissions and increasing nutrient use efficiency in animal diets. Additionally, it can be utilized for hay and silage, possesses anthelmintic properties, and supports soil conservation and wildlife habitats. Its prolonged flowering period may also influence plant-pollinator interactions.

With the impending implementation of the EU Biodiversity Strategy for 2030, there is a growing focus on preserving permanent grasslands and promoting regional seed multiplication systems to support native plant gene-pools. Moreover, scientific information on seed multiplication characteristics for most local plant species is insufficient.

This study delves into the seed characteristics of 43 wild ecotypes of bird's foot trefoil collected from semi-natural grasslands in Lithuania. Utilizing a multidisciplinary approach, phytosociological studies were conducted, and grassland communities were classified based on traditional principles of the floristic-phytosociological approach. The variance in 1000 seeds weight was investigated and correlated with the floristic groups of grasslands. We hypothesize that the weight of seeds may be indicative of soil or climate adaptability, reflecting the genetic diversity within populations of *L. corniculatus*. By comprehending these associations, breeders can access a broader genetic pool of *L. corniculatus*, potentially leading to the development of breeding lines with enhanced productivity and resilience. This study aims to identify naturally occurring variations in seed weight that can be harnessed in breeding programs to advance the agricultural potential of bird's foot trefoil.

Keywords: *Lotus corniculatus*, Ecotypes, Seed Morphometry, Plant Communities

FOOD WASTE SORTING BEHAVIOUR: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

About 2.5 billion tons of waste are generated annually in the European Union (EU). Among it, food waste amounts to 88 million tons. Food waste is associated with significant social, economic, and environmental impacts, including the formation of greenhouse gas emissions (GHG) as well as waste of relevant resources. The latest studies demonstrate that food waste is responsible for 15 to 16% of total GHG emissions of the entire food supply chain. When solving the problems, a waste management system is being developed. Recent developments in the EU waste management policy have requested to make it more effective by obliging households to sort food waste. Considering the fact that sorting food waste is a completely new experience in many countries, it is relevant to understand how it should be done in the context of sustainable development and circular economy. Responding this, a set of studies is planned in the area. With this presentation, a scientific debate on the concept of food waste and underlying theories of food waste sorting behaviour is initiated. In detail, it aims at the determination and classification of food waste, as well as the identification and comparison of key theories explaining food waste sorting behaviour. For this purpose, a systematic literature review method is applied. The results of food waste concept determination disclosed the content and constituent parts of food waste, as well as its place and role in a circular food supply chain. The analysis of theories of food waste sorting behaviour allowed identifying variety of factors that influence on waste sorting behaviour and showed heterogeneity in food waste sorting behaviour among segments of households. Findings suggest that households should be addressed with different policy measures to improve food waste sorting and reduce food waste. Thus, as food waste sorting is a new and important part of municipal mixed waste sorting, in future research it is important to understand and examine: a) the waste management systems applied; b) the policies applied; c) the impacts of policy measures on the volume of food waste sorting (possible economic and social impact mechanisms applied by central and municipal level authorities); d) an assessment of the moral and psychological decision of a person to sort food waste.

Keywords: circular food supply chain, food waste, households, theories of food waste sorting behaviour.

EFFECTS OF PLOIDY ON PHYSIOLOGICAL PERFORMANCE OF *HEMEROCALLIS* PLANTS UNDER WATER DEFICIT

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ABSTRACT

Hemerocallis spp. is a popular garden plant with different ploidy and breeding backgrounds of nearly 100,000 registered cultivars, making it an ideal ornamental plant. Chromosome duplication in model plants has a high potential for increasing resistance to abiotic stress. Drought tolerance is crucial to plant survival, productivity, and appearance. The aim of the study was to analyse the morphological and physiological responses in diploid and tetraploid populations of daylily cultivars under water deficit conditions.

Adaptation of daylilies to increasing water deficits at the population level (23 diploid (2x) and 22 tetraploid (4x) cultivars) was utilised in greenhouse conditions measuring relative water content (RWC), reactive oxygen species (ROS) such as O2 and H2O2 accumulation in leaves, plants height, pigment content indices such as chlorophyll, flavonoid and nitrogen balance indexes, as well as photosynthetic parameters. Measurements were made at two drought conditions when treatment plants soil moisture reached 25% (abnormally dry) and 10% (severe drought), while control plants were at 45% (standard irrigation).

During severe drought stress, diploid and tetraploid plants experienced decreased relative water content, with diploids showing a 20% decrease and tetraploids showing an 11% decrease. Abnormally dry conditions did not affect relative water content. Tetraploid plants showed a 33% increase in O2 levels during severe drought, while diploid plants showed no changes. Severe drought also increased H2O2 concentration in diploid plants but did not affect tetraploid plants. Diploid and tetraploid plants observed a decrease in plant height, with a 15% and 11% decrease in abnormally dry conditions and a 32% and 28% decrease in severe drought conditions, respectively. The chlorophyll index increased by 9% in severe drought conditions for both plant groups, but tetraploids showed a slightly lower increase at 6%. The flavonoid and nitrogen balance index in tetraploid plants increased by 13% in severe drought. The photosynthetic rate decreased significantly in both diploid and tetraploid plants during abnormally dry conditions, with diploids experiencing a more significant decrease of 60% compared to tetraploids at 42%. Transpiration rate decreased in both plant groups during abnormally dry conditions, with diploids showing a 52% decrease and tetraploids showing a 48% decrease. With prolonged drought leading to severe drought conditions, diploids had a higher decrease in transpiration rate at 78% compared to tetraploids at 63%. Tetraploid plants had slightly elevated leaf temperature during abnormally dry conditions. Water use efficiency (WUE = photosynthetic rate/transpiration rate) in abnormally dry conditions in tetraploid plants was 3.8 times higher than in well-watered tetraploid plants. Stomatal limitation (Sl= Ci/Ca, where Ci is intercellular CO2 concentration, and Ca is atmospheric CO2 concentration in abnormally dry conditions in the tetraploid plant group decreased by 8.5 times, while diploids showed no changes.

The findings highlight the importance of considering ploidy levels when selecting and cultivating drought-tolerant varieties in water-deficit areas, as tetraploid plants exhibit some advantageous physiological responses compared to diploid plants. This could have significant ecological and economic benefits regarding irrigation practices, as tetraploid plants may require less water to maintain their growth and development. Further research could help elucidate the underlying mechanisms that contribute to the improved drought tolerance of tetraploid plants and facilitate the development of more resilient crop varieties in the face of climate change.

Keywords: Relative Water Content, Photosynthetic Rate, Reactive Oxygen Species, Plant Physiology, Polyploidy

SOC AND WEOC IN THE SOIL UNDER DIFFERENT COMPOSITION SWARDS

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ABSTRACT

Agricultural soils are often discussed as one area that can contribute to reducing greenhouse gases from the atmosphere. There are many suggestions on how to achieve this goal. As one of them, swards of perennial grasses are planted or restored, and these plants are also included in agricultural crop rotation. After three years of growing, this study investigated dissimilarities in soil organic carbon (SOC) and water-extractable organic carbon (WEOC) in an arable field occupied by mono-component and bi-component swards. Considering the different biological properties of plants and the changing climate, the following grasses were chosen: timothy (*Phleum pratense* L.), red clover (*Trifolium pratense* L.) and their mixture; tall oat grass (*Arrhenatherum elatius* L.), alfalfa (*Medicago sativa* L.) and their mixture. The results of swards soil analyses were compared with those of periodical cultivated plots in the same area (the fallow) results. The experiment was established at Lithuanian Research Centre for Agriculture and Forestry, Kedainiai district, Lithuania on a *Cambisol*. Soil samples for the chemical analyses were taken with a steel probe tool from three replicates of the soil (0–10, 10–20, and 20–30 cm) in the autumn of 2023. The content of SOC was defined according to the Nikitin modification of the Tyurin dichromate oxidation method. The WEOC measurement procedure was performed based on the IR detection method after UV-catalyzed persulphate oxidation in a nitrogen environment. During this process, WEOC is oxidized to carbon dioxide and measured operating the ion chromatograph (SKALAR, Netherlands). The content of nitrogen (N) in the soil was determined by the Kjeldahl method using a spectrophotometric measurement. For one-way analysis of variance (ANOVA), the software SAS Enterprise, version 7.1 (SAS Institute Inc., USA) was used. Differences among means were evaluated by Fisher's test ($p < 0.05$). Considering SOC results, statistically significant differences were found between the soil under fallow and all swards, regardless of their species composition. SOC accumulated the most in the bi-component swards. The amount of WEOC in the soil varied from 0.175 to 0.271 g kg^{-1} depending on the soil depth and the grasses in the field. In this study, a C to N ratio was also calculated to predict the carbon storage potential in the soil. However, the period of three years was too short for the newly established swards to reveal differences determined by the species composition of the swards. The continuation of the study is required.

Keywords: carbon sequestration; mono-component swards; bi-component swards; tool oat grass.

PEATLAND LOSS AND RESTORATION POTENTIAL IN LITHUANIA

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ABSTRACT

Peatlands cover only 3% of the world's land surface but have a significant role in the global processes. They provide many ecosystem services, such as water sources, waste treatment, water flow regulation, biodiversity, and recreation. Relative to their size, peatlands also play a critical role in climate regulation acting as carbon sinks. Despite their importance, peatlands are under threat due to land use change and climate change. Since 1900, Lithuania has lost around 75% of its peatlands, making their protection and/or restoration an important goal in the future. The latest and historical data on peatlands in Lithuania was used in this study, as well as studies evaluating ecosystem services provided by peatlands. Data analysis was done with R to find the patterns of change in peatlands such as land use conversion and ecosystem service provision. Of the 3 peatland types (fen, transitional, bog), 74% of fen area has been drained while around 65% of the raised bog area is non-drained. Most of the drained peatlands have been converted into forest (44%), grassland (24%), and cropland (16%). 40% of all non-drained peatlands are in protected areas, ensuring their stability. Currently, the remaining non-drained peatlands covering 210 000 ha provide $1 336 million/year of ecosystem services. 444 000 ha of drained peatlands currently provide $1 206 million/year in ecosystem services. If restored, these drained peatlands would provide an additional $2 833 million/year. Restoration would especially benefit the carbon balance, as it would increase climate regulation services by $824 million/year. The estimated rewetting cost of peatlands is $351 million which makes up a fraction of their potential ecosystem service value and would greatly benefit the total value of ESV in Lithuania.

Keywords: peatlands, wetlands, carbon sequestration, climate change mitigation, ecosystem services

DYNAMICS OF FUNCTIONAL GROUP COMPOSITION IN GRASS - LEGUME MIXTURES

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ABSTRACT

Over the last few decades, the primary goal of forage production has been to maximize energy content demanded by intensive milk and beef farming. This management resulted in a limited number of cultivated species which in turn led to a heavy reliance on mineral fertilizers. However, shifts in agricultural policy, economic factors, and the effects of climate change have prompted a reconsideration of the practice and emphasized the importance of reintroducing alternative forage species to enhance biodiversity in agroecosystems. The aim of the study was to evaluate the composition of mixtures focusing on minor forage crop species, such as birdsfoot trefoil (*Lotus corniculatus*) and tall fescue (*Festuca arundinacea*) and their persistence, plasticity, and adaptability to unfavorable environmental conditions. Grazing, hay/silage and a universal type of grasslands were designed as trinary and quaternary mixtures consisting of three legumes and five partner grass species. The cultivars and breeding lines were selected based on their superior productivity and Lithuanian origin: minor species - tall fescue (*Festuca arundinacea* cv. Monas), birdsfoot trefoil *(Lotus corniculatus* breeding line), and main species - red clover (*Trifolium pratense* cv. Arimaiciai), white clover (*Trifolium repens* cv. Nemuniai), perennial ryegrass (*Lolium perenne* cv. Elena DS), meadow fescue (*Festuca pratensis* cv. Alanta), Festulolium (*Festulolium* cv. Punia DS), timothy (*Phleum pratense* cv. Zolis). Plots were harvested when first-flowers of legume emerged, and subsequent harvests were done at intervals of 40 to 50 days. The number of germinated plants was assessed 30 days after sowing, and recorded as the number of plants per square meter. The botanical composition of mixtures was determined by weighing herbage at the first and last cut of the season, by estimating comparative weight of functional groups. The germination of the legumes ranged from 44 % to 22.8 % where the forage-type mixture composed of red clover, perennial ryegrass, and meadow fescue exhibited the highest germination percentage. Grazing type mixtures containing red and white clovers, tall fescue and Festulolium germinated the worst (22.8%), while mixtures of universal and grazing type with birds-foot trefoil had high percentage (42 and 41%) of germinated legumes. Summer drought was the main factor affecting botanical composition dynamics over the vegetative season and mixtures containing birdsfoot trefoil suffered the most (8.5-14.20% of the legumes). In the late summer, the recovery of forage type mixture with red clover was better ($p>0.05$) compared to mixtures with birdsfoot trefoil. Results showed that grasses generally thrived better under drought, with mixtures containing white clover being less affected. The proportion of companion species and its competitiveness should be considered in order to maintain desirable percentage of legumes in the mixtures. Diversifying forage crop species in grasslands could enhance resilience and productivity in livestock farming systems, particularly in the face of climate challenges.

Keywords: grassland, red clover, birdsfoot trefoil, minor species, drought

PINUS SYLVESTRIS BREEDING FOR RESISTANCE AGAINST NATURAL INFECTION OF THE FUNGUS *HETEROBASIDION ANNOSUM*

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ABSTRACT

Increasing resistance against biotic and abiotic factors is an important goal of forest tree breeding. The aim of the present study was to develop a root rot resistance index for Scots pine breeding and evaluate its effectiveness. The productivity, branch diameter, branchiness, stem straightness, spike knots, and damage from natural infection of root rot in 154 Scots pine open-pollinated families from Latvia were evaluated through a progeny field trial at the age of 38 years. Trees with decline symptoms were sampled for fungal isolations. Based on this information and kriging estimates of root rot, 35 affected areas (average size: 108 m^2; total 28% from the 1.5 ha trial) were delineated. The resistance index of a single tree was formed based on family adjusted proportion of live to infected trees and the distance to the center of the affected area. Heritability for resistance to root rot, based on the value of this index, was high (0.37) and comparable to indices of growth traits. Correlations of family breeding estimates between resistance to root rot and the other traits were not significant, except for a weak, yet significant, positive correlation with diameter at breast height and branch diameter. The selection index, including only growth traits (height and stem volume), had a negligible effect on damage by root rot. We detected a maximum genetic gain in the resistance index of 33.7% when incorporating it into the selection index with positive gains for growth traits (6.5–11.0%). Two-stage selection with a prior selection of the most resistant families was not superior to the use of the selection index with only rot resistance included. Overall, the rot resistance index appeared to be an effective tool in tree breeding for the selection of more resistant families, using the existing trials with natural (uncontrolled) infection.

Keywords: selection index; root rot; growth; genetic gain; two-stage selection; heritability