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IN SCIENCE & TECHNOLOGY
ZERO WASTE
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ISTANBUL2023

International Sustainable Resource Recovery Strategies Towards Zero Waste (FULLRECO4US) Conference

13 – 15 September 2023

Istanbul, Turkey

Preface

On behalf of the organizing committee, I would like to welcome all participants and speakers to the International Sustainable Resource Recovery Strategies Towards Zero Waste (FULLRECO4US) Conference in Istanbul/Turkiye. This conference is the first international conference under Cost Action 20133: Cross Border Transfer and Development of Sustainable Resource Recovery Strategies Towards Zero Waste (FULLRECO4US) and I hope it will be the starting point for a series of FULLRECO4US conferences. It is my pleasure to thank COST Action 20133 (funded by the European Union) for their financial support.

FULLRECO4US Istanbul 2023 conference provides a unique opportunity for professionals from around the world to learn, share and present the latest knowledge and insights on circular economy, zero waste, resource recovery strategies, energy resources and sustainable food systems. The conference is a networking platform with the world's leading experts in resource recovery strategies and related fields. It is an important event for assessing the key challenges in promoting a sustainable zero waste bringing together an international community of leading academics, researchers, engineers and industry professionals to exchange and share their ideas and experiences.

This conference was organized in Istanbul by Innobrane Research Group led by Derya Y. Koseoglu-Imer and Bilig Upcycling Academy. The local organizing team, which are members of Innobrane Research Group, consists of Derya Y. Koseoglu-Imer (conference chair), Sama Al-Mutwalli (conference secretariat), Tugba Sapmaz-Wikstrom (conference secretariat), Mustafa Taher (conference secretariat), Elifnur Gezmis Yavuz, Esra Buyukada Kesici, Feyza Nur Buyuknalcaci, Sezer Gencturk, Yasin Sahin, Duygu Tozaraydin, Cagri Kaan Kilic. There was also an international organizing committee composed of 10 members from 9 different countries: Mohammad Taherzadeh (SE), Philippe Corvini (CH), Pieter Billen (BE), Olga Nunes (PT), Jorge Marchetti (NO), Patrik Lennartsson (SE), Timo Kikas (EE), Belen Garcia (ES), Gjore Nakov (BG), Derya Y. Koseoglu-Imer (TR). The scientific committee of the conference included 120 reviewers from 36 countries. We had 2 plenary speakers, 7 keynote speakers, 7 stakeholders, 57 oral presentations, and 51 poster presentations and more than 200 participants from 35 countries. The conference showed a good balance in terms of gender equality: 57% of the participants were women and 43% were men.

It is my pleasure to thank Prof. Mohammad J. Taherzadeh (COST Action Chair) and all members of the core group and management committee of COST Action-20133, members of local organizing team, all participants, stakeholders, Kolektif House, Bilig Academy and Crowlink who contributed to success of this conference.

Istanbul is truly a crossroads of ideas and cultures between Europe and Asia. I hope that all participants had good memories of the FULLRECO4US Istanbul Conference.

See you again in Istanbul, Sincerely

Assoc. Prof. Dr. Derya Y. Koseoglu-Imer (Conference Chair)

FULLRECO4US Istanbul Conference 2023

Assoc. Prof. Dr. Derya Y. Koseoğlu Imer

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Istanbul Technical University
Turkey

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Plenary Speakers

Prof. Mohammad J. Taherzadeh
University of Boras
Sweden

Mohammad J. Taherzadeh is professor in Bioprocess technology since 2004 at University of Borås in Sweden and chairman of Swedish Centre for Resource Recovery. Prof. Taherzadeh has PhD in Bioscience from Sweden, and MSc and BSc in Chemical Engineering from Iran. He is developing processes to convert wastes and residuals to value added products with focus on pretreatment and fermentation using bacteria and filamentous fungi. He is also chair of COST Action FULLRECO4US. He has more than 400 publications in scientific peer-reviewed journals, 40 book chapters, 8 books.
More information about him at www.taherzadeh.se

Burak DALKILIÇ
Akkim Kimya Sanayi A.Ş.
Turkey

Burak DALKILIÇ is a seasoned expert in water treatment technology with a strong focus on sales and marketing. As the Water Solutions and Membrane Technologies Group Manager at Akkim Kimya Sanayi A.Ş., he leads sales efforts across three key divisions, including Ultrafiltration Membranes and Water Chemicals. Burak's pioneering contributions include spearheading hollow fiber membrane production at Ak-Kim, positioning the company as a leader in Turkey's water treatment sector. His leadership and strategic prowess continue to drive advancements in the field.

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Keynote Speakers

Assoc. Prof. Dr. Derya Y. Koseoğlu Imer
Istanbul Technical University
Turkey

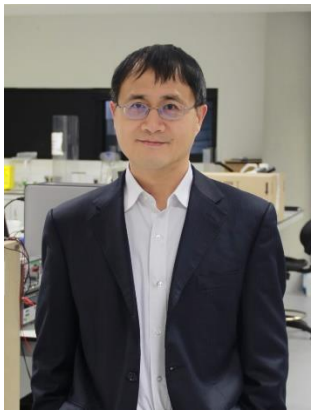
Derya Y. Koseoglu-Imer is the faculty member in Environmental Engineering Dep. at Istanbul Technical University. She is focusing working on the intersection of environmental engineering and material sciences for ”innovative and sustainable separation materials development” and collaborated with many national/international researchers in project partnerships and joint scientific work. She is working on the development of separation technologies for water and air application with sustainable and circular design and the use of new eco-friendly/biobased/green materials at fit for purpose. She is the group leader of innobrane research group (http://innobrane.com/)

Prof. Dr. Timo Kikas
Estonian University of Life Sciences
Estonia

Timo Kikas received his PhD degree from Georgia Institute of Technology, USA in the field of Analytical Environmental Chemistry. He has worked as a researcher in USA, Japan, Finland and Estonia. He has also been a director of Türi College of Tartu University and Study Program manager of Environmental Engineering curriculum at University of Tartu. Presently, he is a Chair Professor of Biosystems Engineering chair in the Institute of Technology of Estonian University of Life Sciences. His main areas of interest include 2nd and 3rd generation bioenergy research, biosensors for environmental monitoring, flow injection analysis and lab-on-valve systems. Prof. Kikas is Editor in Chief of Agronomy Research journal and a guest editor of Energies, a member of the Board of Institute of Technology and the Board of Estonian University of Life Sciences, and national task leader of IEA Bioenergy Task 37 Biogas. Prof. Kikas has been awarded twice with the stipend of Estonian World Council. He is also a recipient of Tartu City Rae Foundation award.

Belén García holds a PhD in Law from Universidad Complutense in Madrid (Spain) and an Executive MBA from IE Business School (Madrid – Spain). Since 2015 she is the managing director of PACKNET – Spanish Packaging Technology Platform, a non-profit association and public-private structure led by industry with over 120 current members up and down the entire packaging value chain that reinforces the links between R&D, innovation and industry, with a focus on medium-to-long-term strategies.

Prof. Dr. Belen Garcia
PACKNET
Spain

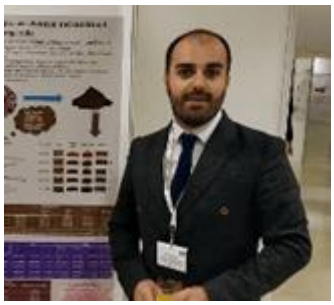


Prof. Xinmin Zhan is Professor in Civil Engineering at the University of Galway, Ireland. He graduated from Tsinghua University, China in 1999 with BE and PhD degrees in Environmental Engineering, and conducted research and worked in Tokyo Institute of Technology (Japan), Gifu University (Japan) and Tsinghua University before working as a researcher at the University of Galway in 2002. Prof. Zhan's research interests include (i) development of efficient and sustainable wastewater treatment technologies; and (ii) recovery of organic waste and biomass for use as a sustainable and clean energy source and for building a greener agriculture industry. He has been PI of over 30 research projects and published over 160 peer-reviewed journal papers, and a monograph Greenhouse Gas Emission and Mitigation in Municipal Wastewater Treatment Plants by International Water Association Publishing. He is one co-inventor of four patents, two of which have been licensed to the industry. Prof. Zhan is an editor of Frontiers of Environmental Science & Engineering, and the Associate Editor-in-Chief of Water Cycle. He is a member of the Engineering and Computer Sciences multidisciplinary committee of the Royal Irish Academy, and is the founding chair of the Chinese-European Society for Environment, Ecology & Sustainability). Prof. Zhan was awarded with several prestigious awards from University of Galway, SFI MaREI research centre, Outstanding Editor of Frontiers of Environmental Science & Engineering, and Japan Society on Water Environment-IDEA Water Environment.

Prof. Dr. Xinmin Zhan
University of Galway
Ireland

Prof. Dr. Céline Vaneeckhaute
Laval University
Canada

Dr. Céline Vaneeckhaute is associate professor at Université Laval in Quebec, Canada and director of the BioEngine Research Team on Green Process Engineering and Biorefineries, composed of over 15 full-time researchers under her principal supervision. She holds the prestigious title of Canada Research Chair in resource recovery and bioproducts engineering. Her main research field concerns the recovery of nutrients, energy and water from waste and wastewater sources. Her innovative work has led to the achievement of numerous prestigious research awards such as the Global Young Leadership award emitted by the International Water Association, the Prix du Québec Relève Scientifique (the highest distinction for scientists awarded by the government of Quebec) and the Prix Honoris Genius Relève (the highest distinction for engineers awarded by the Quebec Order of Engineers). She is steering board member of the International Water Association Resource Recovery from Water Cluster President of the Waste and Energy Management Division of the Food Production Topical Team at the Canadian Space Agency, to name a few. Prior to her occupation as a Professor, she was assistant director for the biomethanation processes at Quebec City. She has also been active as an independent consultant in the field. Dr. Vaneeckhaute holds a double PhD degree in water engineering at Université Laval and applied bioscience engineering at Ghent University (Belgium).



Assoc. Prof. Dr. Gjore Nakov
Technical University of Sofia
Bulgaria

Gjore Nakov is currently an Associate Professor at the Department of Pedagogy, Food Technology and Tourism at College – Sliven. He was appointed as an external Associate Professor at the University Ss. Kliment Ohridski – Bitola, R.N. Macedonia at the Faculty of Technology and Technical Sciences. For the last several years, Dr. Nakov worked on valorisation and incorporation of food by-products in the production of new functional and innovative food products. He is also the coordinator of two national projects. He is part of the Management Committee from Bulgaria in two COST Actions (CA 20133 and CA 20128). So far, Dr. Nakov is the author of 78 scientific papers. He is an Editorial board member of the International Journal of Natural and Engineering Sciences (IJNES) from Türkiye.

Pieter Billen is associate professor at the Faculty of Applied Engineering at the University of Antwerp in Belgium. He is a chemical engineer, focused on smart molecules management. He leads the research group iPRACS, which bridges the gap from molecules to processes, in order to create sustainable novel value chains for organic materials. The group has several projects on the chemical recycling of polymer waste, and is creating novel generic feasibility assessment methods based on quasi-thermodynamics.

Assoc. Prof. Dr. Pieter Billen
University of Antwerp
Belgium

Mehmet Kitis is professor in Dept. of Environmental Engineering in Suleyman Demirel University, Türkiye. He has a Ph.D. degree in Environmental Engineering and Science from Clemson University, USA. He worked as a process engineer in CH2MHILL Inc., CA USA. His main research areas include membrane processes, wastewater reclamation and reuse, industrial cleaner production applications, industrial water efficiency, disinfection by-products, advanced treatment processes. Prof. Kitis has published 118 peer-reviewed papers and books/book chapters. He presented more than 200 conference papers. He worked in 73 national and international research and engineering projects. Prof. Kitis has received 26 national/international scientific/engineering awards. He has advised a total of 29 M.Sc. and Ph.D. thesis. He has involved in a total of 47 technical/academic/social/administrative positions including department chair, vice rector, consultant to ministries, international companies and various industries, research institute director (TÜBİTAK MAM), editorial board member, chamber of commerce advisor, and others. He has been making research and consulting for more than 25 years, mainly in the areas of water and wastewater treatment, watershed management and industrial cleaner production applications.

Prof. Mehmet Kitis
Suleyman Demirel University
Turkey

FULLRECO4US Istanbul Conference 2023

Stakeholder Speakers

Elif Ecem Esenboğa Kanyılmaz (TR)
TUPRAS Oil Industry
R&D studies carried out within the scope of circular economy in the oil and gas industry

Tunay Carpar (TR)
Istanbul Water and Sewerage Administration (ISKI)
Assessing the resource recovery activities in public institutions: The case of ISKI

Ahmed Rassili (BE)
CRM Group
Circular economy and energy shift activities @ CRM Group

Ernes Cereku (NO)
GTT Energy-NG Group
Waste Management in Norway: From the lenses of NG Group

Emin Ali Sipahi and Münevver Alpaslan (TR)
MSA x COOK x DAMLICA
FARM – Compost Project

Aintzane Esturo (ES)
International Fruit and Vegetable Juice Association
Towards sustainability in the fruit juice industry: opportunities of waste reduction through circular economy

Feyza Nur Buyuknalcaci (TR)
Istanbul Project Academy
HORIZON EUROPE Collaboration

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Waste-to-Value Food Acceptance in Montenegro and Bulgaria: Identifying Clusters of Consumer Behaviour

Suncica Rogic [a], Myriam Taghouti [b*], Gore Nakov [c], Milena Djukanovic [d]

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Abstract

Waste valorization is among the promising solutions to residues problems. However, the success of upcycling technologies ultimately depends on consumer acceptance and uptake of final products. This study investigates how consumers in Montenegro and Bulgaria perceive upcycled food, seeking to i) examine their perceptions, awareness, and attitudes towards waste-to-value food, ii) explore potential inhibitors and drivers impacting the uptake of such products.

A survey-based methodology was used to collect information from a wide range of consumers. To understand the various patterns of acceptance and perceptions toward waste-to-value food, it is necessary to identify consumer groups depending on their behaviour to further evaluate the potential commercial feasibility of such products.

To group customers, clustering analysis was made, using k-means clustering data mining method. The optimal number of clusters was obtained using Davies-Bouldin index. Then, customers were classified into derived clusters using the Decision tree method (DT), based on the other variables.

Analysing the survey data revealed the presence of two consumer clusters in the 2 countries regarding their acceptance and perceptions towards waste-to-value food. Indicating a more sustainable behaviour, the first cluster showed a higher positive perception and readiness to try upcycled food. But, the second cluster showed less environmentally friendly behaviour and lower level of support for waste-to-value food. Next, classification was performed based on other attributes, resulting in a DT classification model with 89.73% accuracy. A total of six rules for classification were extracted from the DT.

For demographic data, participants were identified as 96 men and 162 women. With 104 responders, the age group18–23 had the greatest participation rate. Also, 92 respondents hold a high education degree. Average awareness level of the participants regarding circular economy, scored an average of 3.01 out of 7. Similarly, their awareness of waste-to-value food stood at an average score of 3.73 out of 7. As a working group in FULLRECO4US COST action, this research attempts to bridge the gap between technology improvements and consumer behaviour. Policymakers, companies, and other stakeholders involved in waste management and sustainability activities can benefit from the insights provided by this research.

International Sustainable Resource Recovery Strategies Towards Zero Waste (FULLRECO4US) Conference
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Properties of biowaste-derived hydrochar as a tool for various environmental applications

Marija Sobic [a*], Mirjana Petronijević [a*], Sanja Panić [a], Nataša Đurišić-Mladenović [a]

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Abstract

Providing enough food for the growing population is accompanied by an increase in the generation of biodegradable agri-food waste. In Serbia, a significant amount of agri-food waste is produced (around 13.8 million tons per year), but only 16.8% of total biodegradable waste is recycled [1].

Two effects can be achieved by valorizing biomass and raising awareness of its importance as a resource: reducing the content of existing biowaste and obtaining new functional products. One of the products obtained by re-using waste biomass is hydrochar (HC), a carbon material obtained through the hydrothermal carbonization (HTC) process, with unique properties suitable for diverse environmental applications. The production process entails the HTC of both dry and wet feedstocks. HTC takes place in relatively mild process conditions (180-250 °C and 2-22 MPa) in the presence of water in a subcritical state, where, in addition to HC, process water and gases are separated.

The properties and yield of HC depend on several factors, such as the type of biomass used, the reaction temperature, and the residence time. When the production takes place at high temperatures (e.g. > 200°C), a low yield of char occurs, but a high carbon conversion is achieved, resulting in chars with high heating value. HC from lignocellulosic biomass has high total carbon content (38-91%) and low ash content (up to 13%). During HTC performed in an aqueous medium, the oxidative functional groups form on the surface of char. HC from agro biowaste has a high specific surface area and pore volume, which can be further improved through activation/functionalization.

Exceptional surface area, porosity, and functional groups make HC useful soil amendments, fertilizers, adsorbents, and renewable energy sources. HC is an effective biosorbent for organic pollutants and heavy metals removal from water, as well as for soil remediation [2]. Utilizing waste biomass for hydrochar production aligns with circular economy principles and promotes sustainable agriculture. This study will contribute to unlocking the potential of HC for a greener and more sustainable future.

[1] http://www.sepa.gov.rs/download/IZVESTAJ_2021.pdf;

[2] A. Khosravi, H. Zheng, Q. Liu, M. Hashemi, Y. Tang, B. Xing, Production and characterization of hydrochars and their application in soil improvement and environmental remediation, Chemical Engineering Journal, Volume 430, 2022, 133142, ISSN 1385-8947.

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Investigation of ammonia recovery from simulated poultry manure via integrated MEC-AD system

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Abstract

Microbial electrolysis cells (MECs) are a type of bioelectrochemical system that use microorganisms to catalyze the conversion of organic matter into hydrogen gas (H_2) through a process known as microbial electrolysis. MECs combine elements of microbial fuel cells (MFCs) and electrolysis cells to achieve this conversion. It can play a significant role in anaerobic digestion processes by enhancing methane production by reacting CO_2 (produced during anaerobic digestion) with bioelectrochemically produced H_2. With the reactions triggered by the electrons provided by the cathode in the MEC, the cations can be made to move. This can enable cations (i.e. NH_4^+) to move in the desired direction.

In this context, a MEC system developed for ammonium recovery (a single-celled MEC and an attached cathode compartment separated by a cation exchange membrane) was used in this study. While anaerobic digestion of simulated poultry wastewater is carried out in the single-cell MEC section, ammonium recovery is achieved in the separate cathode section. For this purpose, the effects of different applied voltages and different ammonium loading rates on anaerobic digestion performance and ammonium recovery were investigated.

The proposed system has a potential for ammonium recovery during the digestion of high nitrogen-containing waste streams.

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Functional biochar-based coating for removal of indoor formaldehyde

Mariem Zouari [a*], Laetitia Marrot [b], David DeVallance [c]

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[b] Slovenian National Building and Civil Engineering Institute, laetitia.marrot@zag.si
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Abstract

With increased industrial activity, emission rates continuously increase, leading to growing environmental concerns. Air pollution, for instance, is a challenging problem, given that poor air quality harms human health and the ecosystem. Formaldehyde is one of the major airborne pollutants that is recognized as a human carcinogen. In this view, efforts have been made to mitigate formaldehyde levels, especially in indoor environments with higher exposure risk. Adsorption on a porous support, such as carbonaceous materials, has been known as one of the most effective air remediation technologies. In this regard, biochar has been widely employed as a potential adsorbent for various air contaminants owing to its large surface area and well-developed porous structure. After the adsorption of a certain amount of pollutants, biochar usually reaches a saturation point when the pores are occupied, and further uptake is impossible. In this case, biochar can be thermally regenerated and reused. However, after several regeneration cycles, biochar starts to lose its adsorptive performance. Indeed, based on our current research, we found that after five regeneration cycles, the formaldehyde adsorption efficiency of biochar decreased by 13%. Therefore, alternative regeneration solutions are required for efficient utilization of biochar in air remediation. Functionalizing biochar particles with active photocatalysts has the potential to extend the lifespan of biochar adsorbents. The principle combines the adsorptive property of biochar and the photodegradation activity of MnO_2 to enable continuous pollutant uptake. During this study, biochar particles were prepared by slow pyrolysis of under-utilized biomass. Biochar wad doped with variable loadings of MnO_2 using the co-precipitation method. The integrated adsorption-photocatalytic degradation efficiency of the functional biochar samples towards formaldehyde was tested in a batch experimental set-up consisting of a closed glass chamber and an electrochemical gas sensor. Tests were performed in dark and visible light conditions. Additionally, the sample with the highest formaldehyde removal performance was utilized to prepare a functional coating. The coating was applied on wooden substrate and its formaldehyde removal capacity was evaluated at indoor conditions. Potential findings of the study will be presented.

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Simulation and study of the effect of geometric parameters on the hydrodynamic behavior of biodiesel production process in SMX static mixer

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Abstract

Renewable energy has never been more important than it is today, as climate change is arguably the world's most fundamental problem to be solved. More than ever, the world is threatened by a heavy dependence on fossil fuels, especially oil and coal. Dealing with this crisis is ending our reliance on fossil fuel energy as the main driver of climate change. Biofuels are an essential renewable energy source and it is predicted that by 2050, 40% of renewable energy sources will be provided from biofuel sources.

the production of high-quality and high-performance biodiesel is very important. Quality biodiesel production depends on several parameters, one of the most important is the proper mixing of oil and alcohol. In these years, many researches have been conducted for the production of biodiesel in STR stirred tank reactors; However, there are few efforts on the design optimization of static mixer for biodiesel synthesis. The mixing of the system depends on the geometry of the channel, the intensity ratio of the currents and the position along the mixing channel. Static mixers are low-power and efficient mixing devices that can perform a wide range of applications and use the energy from the flow to produce the desired mixing during the process. The type of static mixer, the number of elements and the speed of the working fluid are the main drivers for the pressure drop of the static mixer and its performance. A low-cost approach to mixing chemical reactors and hydrodynamic studies is simulation using Computational Fluid Dynamics (CFD), which is advantageous over experimental tests. The process and principles of simulation were done with CFD software in Ansys Fluent. The settings made in Fluent software for the numerical analysis of SMX mixer mixing. This study first used AnsysFluent software to simulate oil-alcohol mixing in an SMX static mixer, and then checked the velocity parameters and length-to-diameter ratio in three levels. Good results were obtained by choosing appropriate values in terms of pressure drop and mixing quality. The current research therefore solves one of the fundamental needs in this field, namely verification of mixing quality in SMX static mixers. The purpose of this project is to study the hydrodynamic behavior of the SMX static mixer using CFD simulations or computational fluid dynamics to check the velocity and pressure drop to determine the optimal mode for mixing oil and alcohol in the biodiesel production process.

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Enhancement of water circularity and food wastes valorisation in the meat industry

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Abstract

The food and beverage industry in Europe accounts for approximately 56% of the water consumption allocated to industrial and urban use, and besides generates a significant amount of food wastes, reaching 30.6 million of tonnes. Particularly noting is the meat industry, where the estimated value of wastes amounts the 18 Mt surpassing the 50% of the total food wastes produced. Also, it is important to highlight that food processing takes the 28% of the energy consumption in the EU's production sector. Thus, it is crucial to implement strategies that promote efficient water usage and circularity of food wastes, incorporating a water-wastes-energy nexus approach. Within the framework of the European Project AccelWater (GA958266), a pilot demonstrator has been installed in MAFRICA slaughterhouse (Manresa, Barcelona, Spain) aiming to treat wastewater from the meat processing industry to obtain high quality reclaimed water, as well as for valorising solid wastes and by-products generated in the same industry reaching a zero-waste approach. Regarding the wastewater treatment, the implementation of innovative treatment line composed by membrane biological reactor (MBR), electrodialysis, and UV treatment to comply with the requirements established for the water reuse Spanish regulation (RD 1620/2007) is being considered. On the other hand, the strategy for valorising solid wastes primarily focuses on energy recovery through the production of biogas using anaerobic digestion processes, coupled with a biogas upgrading unit for valorising biomethane. By this way, carbon dioxide will be recovered for pig stunning activities. Additionally, solid wastes valorisation also involves the production bioproducts with agronomic interest, such as biostimulants (protein hydrolysates) and nutrient-rich organic amendments, through solid-state fermentation or biodrying. Furthermore, energy in form of biomass fuel will be also recovered by using biodrying. Altogether, the operation of this pilot plant represents a significant milestone for MAFRICA allowing for the recovery of the 40% of generated wastewater to be reused in its installations, converting the 20% of the solid wastes into energy sources, and producing fertiliser products to be used for agricultural purposes. This research is funded by the European Union's H2020 research and innovation program (Grant Agreement No. 958266).

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Integration of olive oil industry wastewaters into biorefinery

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Abstract

While olive oil is an important food product in the Mediterranean Sea Basin, olive oil mill wastewater (OOMW) and olive pomace, by-products of olive oil, are released in excessive quantities. OOMW is an important source of environmental pollutants due to its slightly acidic pH, high phenol content and high chemical oxygen demand (COD). To overcome this problem, in this work, it was aimed to investigate the potential use of OOMW as an alternative substrate for production of protein rich biomass and bacterial cellulose by filamentous fungi and an acetic acid bacterium, respectively. Additionally, extracts of OOMW against selected microorganisms were examined to determine their use for industrial applications. The results indicated that OOMW needs nitrogen supplementation for microbial production processes. On the other hand, extracts of OOMW showed significant antibacterial activities with high phenolic contents. Overall, it can be concluded that OOMW can be integrated into biorefineries for both microbial production and extraction processes and the resulting products can be used as additives in the food, cosmetic and pharmacology industries.

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Molecular hydrogen production by Escherichia coli wild-type and mutant using spent coffee grounds under different pH conditions

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Abstract

Coffee is a widely consumed beverage and commodity, with an estimated 3.5 billion cups consumed daily. The goal of this study is to determine the optimal conditions for maximizing hydrogen production using different pH levels. To optimize the process, glycerol at a concentration of 10 g/L was added to a solution (coffee waste (40 g L^{-1}) treated with sulfuric acid (7.36 g L^{-1})).

During the growth of E. coli, the redox potential (ORP) was monitored using redox electrode for hydrogen production determination and pH using ion-selective electrode.

pH 6, pH 7 and pH 8 were selected for analysis: In all conditions during the growth of wild-type molecular hydrogen production started from the 3rd hour of growth in both samples with or without glycerol. At pH 7 in wild type cells, with or without glycerol, maximum hydrogen yield was 5.21 mmol L^{-1}, and 2.16 mmol L^{-1} and 5.42 mmol L^{-1} at pH 6 and pH 8 conditions, respectively.

In septuple mutant, hydrogen production began from the 6th hour of growth in all pHs, and the maximum yield was 5.4 mmol L^{-1} at pH 7. In this mutant, hydrogen production lasted until the 168th, 144th and 72nd hour of growth, at pH 7, pH 6 and pH 8, respectively.

At pH 6 and pH 8 hydrogen yield was comparatively lower compared to pH 7. Thus, in the septuple mutant, hydrogen production was observed for a longer time and with a greater yield compared to the wild type.

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Extraction Of Bioactive Principles Using High Pressure Fluid Extraction

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Abstract

Due to global demands aimed at reducing carbon emissions, it is very important to develop environmentally friendly and toward zero-waste technologies. Obtaining biologically important compounds avoiding the process of chemical synthesis is in the focus of science. The chemical synthesis of biologically active compounds requires a large number of steps in which a large number of intermediate products are formed and large amounts of solvents are consumed. In this respect, extraction is a promising tool. However, performing the extraction process in a traditional way is not acceptable from the aspect of environment, but also human health. The biggest drawback is reflected in utilization of volatile (and very often toxic) solvents, low efficiency compared to the consumption of material, time and energy. Precisely for this reason, the concept of extraction requires their replacement with alternative ones, and fluids in the sub/supercritical state are promising. In this paper, the advantages and disadvantages of supercritical carbon dioxide extraction (SFE-CO_2) as well as pressurized liquid extraction (PLE) for obtaining biologically active compounds from *Glaucosciadium cordifolium* were examined. SFE-CO_2 was performed at a temperature of 50°C, under the pressure of 300 bar for 5 hours, while the PLE was performed under the pressure of 1500psi and elevated temperature of 120°C. The obtained extracts were examined in terms of biological activities, and the chemical composition was analyzed in detail using LC-MS/MS. The obtained results were compared with other modern and traditional techniques. The obtained results showed an extremely high level of bioactive compounds in the extracts obtained with fluids under pressure, which was also reflected in their high biological activity, especially towards clinically important enzymes (amylase, glucosidase, tyrosinase, acetinholinesterase). Based on the obtained results, it can be concluded that high-pressure techniques can be consider as green future when it comes to obtaining high-value chemicals and they show a great application character in various branches of industry.

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Hydrochar production from waste lignocellulosic biomass with recirculation of process water

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Abstract

The utilization of biowaste and its transformation into alternative sources of energy is a trend, which could help reduction of carbon emissions and support increasing demand for energy, as well as to solve the growing environmental problems related to solid waste. One of the alternative sources of energy is hydrochar (HC) which is produced using hydrothermal carbonization (HTC) of various wet biomass wastes. During the HTC process, process water in subcritical state is used as a reaction medium to convert biomass into HC. Process water from HTC represents a liquid by-product, rich in organic (polyphenols, flavonoids, dietary fibers, etc.) and inorganic compounds that can have negative impacts on the environment if the water is not properly managed. One of the ways to avoid contamination by releasing process water into the environment, as well as the application of expensive treatments for its purification, is to repeatedly use it in HTC process (i.e. recirculation). The reuse of process water in HTC has been gaining interest due to its potential contribution to the circular economy (closing the water loop), environmental protection, and health. In this paper, the characteristics of the HCs obtained with the recirculation of process water in four consecutive cycles are examined. The HTC process was carried out in a commercial stainless-steel reactor at 300 °C, a pressure of 20 bar (autogenous pressure), while a solid/liquid ratio was 1:15. Waste wood biomass was used as feedstock. The yield of HC in the first run was 40%, while the carbon content was amounted to 79 wt.%. Furthermore, the obtained HC was characterized with relatively high higher heating value (HHV) of 2561 kJ/100 g. In the case of the HTC process with process water recirculation, an increase in the HC yield was recorded for all the runs (up to 10%), while the carbon content remained at the approximately same value. During the process with recirculation, HHV value increased with increasing the number of recirculation cycles (up to 3095 kJ/100 g in the fourth cycle), which indicates that organic matter from the liquid phase has been incorporated into the HC structure contributing to its yield, as well as its quality as an alternative source of energy.

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Single cell protein as alternative upcycled feed ingredient – five decades of research

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Abstract

During the 1960s, the term single-cell-protein (SCP) was coined to describe protein from microorganisms namely algae, fungi, yeasts and bacteria. Since then, several products were developed but the interest in SCP production and use as animal feed ingredient has notably increased during the last decade. SCP is a promising sustainable substitute of conventional protein, especially under the challenging increasing global demand for high-quality protein sources and the feed-food competition.

SCP might be considered an excellent solution for protein supply since it can be produced while addressing simultaneously environmental burdens. In fact, different substrates that are used to cultivate the micro-organisms are mainly side-stream products and agro-industrial wastes such as by-products from crop production and processing.

Several parameters should be optimized to improve the nutritive value of SCP, according to the substrate and the microorganism. Fermentation process requires definition of the inoculum size, incubation time and temperature. Protein content, production costs and scale-up depend on the different industrial requirements such as drying and protein separation.

SCPs are used in aquaculture fish, poultry, and swine diets mainly in substitution to fishmeal and soybean meal. Including SCP in the diets improved growth performance, feed efficiency, and nutrient utilization, while it reduced the environmental footprint of livestock farming. Also, adequate SCP dietary levels resulted in better meat and fish filet quality, mainly with significant improvement of fatty acids profiles. However, further research is needed to optimize SCP inclusion levels and to evaluate the long-term effects of SCP on animals' health and performance.

Waste upcycling processes that generate SCP as a supplementary co-product present more sustainable solutions than those focusing on livestock feed only, offering opportunities of industrial symbiosis and circular economy.

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Critical Roles of Microorganisms in Zero Waste Strategies

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Abstract

Nowadays, zero waste is a challenging concept in many countries, particularly in developed countries, to modify current waste management systems or replace them with more sustainable approaches. Based on the main attention, various definitions have been demarcated for zero waste. In general, zero waste includes various waste management strategies to prevent waste production, recycle and reuse collected waste, improve conventional waste treatment approaches, and relook at waste as a valuable resource instead of an issue. These strategies can be employed for industrial sectors, homes, schools, universities, and social communities. However, these zero waste strategies may seem more complicated in practice and still need investigation and additional work. Among these strategies, biological ones attracted many researchers' attention due to the substantial capacity of microorganisms for resource recovery and waste management in the biorefinery platforms and circular economy. Different microorganisms and their consortia, including algae, bacteria, yeasts, filamentous fungi, etc., are used for recycling, upcycling into value-added products, and resource recovery of various wastes. These microorganisms can be added to the wastes under controlled conditions, or indigenous microorganisms of waste residues can be enriched to perform the desired process. During waste recycling, microorganisms are a promising choice because they decompose waste materials to provide carbon and energy sources for their growth through biodegradation, biodeterioration, or bioassimilation processes. For upcycling of wastes, particularly food wastes, microorganisms play a critical role as they can convert wastes into value-added materials such as enzymes, antioxidants, acids, biofuels, etc. Moreover, edible biomass of filamentous fungi grown on food waste residues (mycoprotein) is a fascinating source to replace plant- and animal-based meats. Along with this waste management strategy, natural lands can be conserved, and domestic animal slaughtering may be reduced or stopped. To put it briefly, the critical roles of microorganisms in zero waste strategies cannot be neglected and profound investigation of microbial processes as well as microbial physiology are essential for higher yield and productivity in a sustainable approach. Furthermore, microbial processes for zero waste strategies can bridge among engineers, industrial stockholders, microbiologists, environmentalists, and activists.

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Valorisation of brewers' spent grain for food and feed applications

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Abstract

Background: Brewer's spent grain (BSG) is the main by-product of beer manufacturing, consisting of the external layers of barley which are separated from the mash before fermentation. Around 39 million tons of BSG is produced annually by the global brewing industry and is generally used for low value applications such as animal feed or disposed off in landfill. In order to combat some of the waste produced by this industry, there is interest in avenues of valorization for this abundant waste product in sync with UN sustainable development goal 12- Responsible consumption and production.

Scope: Treatment of BSG with various proteases (Novozymes) may solubilise protein, yield bioactive peptides as well as solubilise entrapped carbohydrate from the grain, whereby the final extract may further be used as a functional food/feed ingredient.

Key Findings: The highest FRAP antioxidant activity was obtained from Pro 5 (4%: 108.10 ± 4.17 µmole TE/g protein or 18.06 ± 0.70 µmole TE/g d.w.). This value was significantly higher ($p < 0.05$) than other protease treated extracts and 3.6 times higher than protease untreated extracts. The highest DPPH scavenging activity was also obtained from the Pro 5 extracts (4%: 0.118 ± 0.006 µg AAE/mg d.w. or DPPH inhibition at 39.0% ± 1.9). Proximate composition showed this extract to contain highest amount of proteins at 21.66 ± 2.71, significantly higher than all other extracts. Color analysis showed the same Pro 5 (4%) extract to be the darkest (L* 53.73) indicating possible presence of dark polyphenols.

Conclusions: The pro 5 extract produced possesses significantly higher antioxidant activity as compared to untreated BSG. The extract also has high percentage of soluble carbohydrate and solubilized peptides and protein that warrant further investigation into their potential bioactivities and applications.

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Assessment of the Implementation of Best Available Techniques for Cleaner Production in the Textile Industry

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Abstract

The Draft IPPC Regulation requires textile manufacturers to comply with the stipulated BATs. The BAT compliance status (total of 488 BATs) of textile facilities was evaluated conducting on-site visits and surveys to 56 facilities operating in 4 different textile sub-sectors and having different production processes. Both the already implemented and potentially to be implemented BATs were determined. It was found that 37% of the BATs included in the survey were already implemented on full-scale in the studied textile facilities. Such percentage cumulatively increased to 88% with the BATs potentially to be implemented in the future, indicating that the textile sector is dominantly willing to implement many BATs for cleaner production and competition aspects. The BATs with the highest implementation ratios (IR) (already implemented) were: following new technologies and developments (IR: 91%), appropriate accumulation, storage and disposal of textile wastes for reuse (IR: 88%), storage of all chemicals according to the instructions given in the material safety data sheets (MSDS) (IR: 86%), preferring substances that can provide resource efficiency in the selection of raw materials and chemicals (IR: 84%), turning off machines in case of no operation or downtime (IR: 82%), prevention of air leaks (IR: 82%). It was found that 25 BATs had lower implementation ratios (IR: 0-43%). Some of these BATs were: installing electrified filters for odor removal and oil recovery in the pre-fixing process, pre-washing before stenters in the pre-fixing process, wastewater reuse after tertiary treatment. The results overall indicated that a significant level of BAT-related investment was already made for cleaner production in the textile industry. The environmental concerns, customer requirements, resource use efficiency, competition, and cost-benefit issues appear to trigger the willingness of the industry to implement BATs. However, the survey results also indicated that there is still much work to do for the implementation of some BATs. Lower IR values for these BATs are mainly due to the following reasons: being a very specific BAT, high capital/O&M costs and long payback period, operational and installation difficulties, limited sectoral know-how and

experience, limited space for implementation, stringent customer requirements, anxiety on possible product quality deterioration, operational blindness, and some other issues specific to sub-sector.

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Cultivation of medicinal mushroom (Reishi-*Ganoderma lucidum*) from hazelnut pruning waste

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Abstract

Hazelnut pruning waste is released by 1.7 milion ton per year and is not used for any purpose. Türkiye and Italy is the responsible for the highest hazelnut production in the world. It may be possible for local people to achieving income by transforming hazelnut pruning wastes into value-added product like mushrooms. The aim of this study was to investigate the cultivation of medicinal mushroom *Ganoderma lucidum* (Reishi) from hazelnut pruning waste. In the study, hazelnut pruning wastes obtained after hazelnut harvesting were evaluated for the first time as mushroom cultivation. The pruning wastes were chipped into small particles. Composts were formed by mixing pruning wastes by 100 %, wheat bran by 1% and gypsum by 1%. The prepared composts were sterilized by autoclaving at 121 °C at 1.1 atmospheric pressure for 90 minutes. The mushroom mycellium inoculated composts were kept at 20 °C and 65% relative humidity. When incubation period were completed, they were kept at 20 °C and 80% humidity. Fructification of mushrooms that have reached a certain maturity were harvested. After harvesting chemical content analysis of mushrooms were done. Addition, total yield, biological efficiency, spawn run time, first harvesting time (earliness), total mushroom time and cap sizes were determined. The study showed that hazelnut pruning wastes could be used for the cultivation of medicinal mushroom (*Ganoderma lucidum*).

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Investigation of Best Available Techniques for Improving Water Use Efficiency in Industries

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Abstract

Freshwater resources, which are already under pressure due to population growth, rapid and unplanned urbanization, and excessive consumption, are adversely affected in terms of both quantity and quality all over the world. Since the use of water is increasing in direct proportion to the increasing industrialization, studies to be carried out for the efficient use of water in the industry make it a priority to examine the use of water consumption on an industrial sectoral basis. On average, 20% of the usable freshwater in the world is used for industrial purposes, and this range varies between 10 and 30% in industrializing countries. Countries need to carry out various water efficiency studies to continue their economic development and to protect accessible water resources. One of these studies is the application of the best available techniques (BAT) for water efficiency in industries. In this work, various BATs were evaluated in detail in terms of increasing water use efficiency in industries. Such BATs were ranked based on their water efficiency performance. The techniques with high efficiencies were determined and suggestions were made to investigate the applicability of them in various industries.

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Tarhana chips supplemented with wheat bran as a healthy cereal-based fermented snack: physicochemical, antioxidant and sensory properties

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Abstract

Tarhana are one of the most widely consumed traditional fermented cereal based food in Turkey. The tarhana chips produced in the form of tortilla chips are quite different from other types of tarhana. In this research, cracked wheat was used in the production of tarhana chips instead of wheat flour used in other types of tarhana. Wheat brans (WB) were used in the formulation of tarhana chips at the levels of 10%, 25% and 50% (w/w). The qualities of those tarhana chips were evaluated from physical, chemical, technological and sensorial aspects. The technological and physical properties of the tarhana chips were found to be acceptable. Moreover, the addition of WB changed the chemical properties of the tarhana chips positively in comparison to the control sample. Sensorial analysis showed that tarhana chips with 50% WB were preferred by panelists. The tarhana chips containing WB exhibited higher antioxidant properties than the control one. The addition of WB also caused to increase of total phenolic content and dietary fiber contents of the tarhana chips. Therefore, the enriched tarhana chips can be suggested as a good alternative for conventional snack foods due to its healthy, nutritious and low-calorie properties.

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Evaluation of Iso Amyl Ester Rosin in MDF (Medium Density Fibreboard) Production

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Abstract

The aim of the study is to investigate the usability of isoamyl ester rosin instead of paraffin in MDF production. Paraffin is added to urea-formaldehyde to give water-repellent properties to MDF. In the isoamyl ester rosin synthesis, rosin, isoamyl alcohol, and other inputs (catalyst/antioxidant, etc.) were used. Isoamyl alcohol is obtained as a result of the fractionation of fusel oil obtained as waste in the bioethanol production process. The optimum conditions for the synthesis reaction were determined as abietic acid-rosin (165mmol), isoamyl alcohol (413mmol) (1/2.5 n), 1.5% P-TSA and 0.15% commercial additive. Esterification reaction was controlled by FT-IR and Mass Analysis and also DSC and TGA analyses were performed for material characterization. Synthesized isoamyl ester rosin was tried as an alternative to paraffin in MDF production (production inputs: fresh wood fibers, 10% UF, isoamyl ester rosin (%1, %1,5 and %2), and as a hardener of UF ammonium chloride aqueous solution, 25% (0.5% according to the amount of solid glue). Some mechanical and physical tests (Thickness (mm), Moisture (%), Density (kg/m^3), Tensile Strength (Internal Bond) (MPa), Elasticity Modulus (MOR) (MPa), Flexion (MOE) (Mpa), Density (kg/m^3) (For Swelling and Dewatering), Swelling-24h (%) and Water Uptake- 24h (%) were applied to the 8 mm thick boards. Isoamyl ester has shown promising results as an alternative to paraffin based on the analysis findings.

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Optimizing Yield and Quality of Fuel Intermediates from Unrecycled Polyolefins through Thermo-Catalytic Pyrolysis

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Abstract

Plastics like HDPE, LDPE and PP are widely used due to their affordability, durability, and versatility. However, the growing demand and production of plastics have created a significant environmental burden through non-recycled plastic waste. To address this issue, the carbon-neutral process of pyrolysis has been proposed as an effective and eco-friendly solution. Pyrolysis allows for the conversion of plastic waste into valuable products, thereby transforming waste into useful resources while minimizing environmental harm. This study optimized pyrolysis parameters for maximum liquid yield at 450 °C in a lab-scale setup. Optimal conditions were determined: 1.1 L/min N_2 flow rate, 1.5 g/min feeding rate, and 25:25:50 wt.% HDPE:LDPE:PP mixing ratio. These conditions resulted in a predicted liquid yield of 74.1 wt.%, which was confirmed by our experiments yielding 73.3 wt.% liquid. In catalytic experiments, ZSM-5 catalyst was used with varying C/P ratios (1/60, 1/80, 1/100). Liquid products were analyzed with GC-MS, FTIR, bomb calorimetry, elemental analyzer, and gas products with GC-TCD.

The results of this study revealed several key findings. It was observed that higher liquid yields were obtained from fresh polyolefins (POs) compared to waste POs, indicating the influence of factors such as volatile content and the absence of additives present in fresh plastics. Furthermore, the production of unsaturated hydrocarbons, which are indicative of secondary reactions in the liquid phase, decreased when fresh and waste plastics were mixed, as opposed to individual polypropylene experiments. The yield of aromatics varied among the different feedstocks, with fresh LDPE, waste LDPE, and waste polypropylene exhibiting aromatic content values of 0.11 vol.%, 0.16 vol.%, and 0.82 vol.%, respectively. Additionally, an increase in the catalyst-to-plastic (C/P) ratio decreased the liquid yield while accelerating gas formation due to secondary reactions. The experiment with the W-C60 achieved the highest aromatic content of 42.4 vol.%.

Overall, these findings emphasize the significance of process conditions and feedstock composition in determining the distribution and quality of products during POs pyrolysis. The insights gained from this study offer valuable guidance for the design and optimization of pyrolysis processes aimed at producing alternative liquid fuels from plastic waste, thereby fostering a more sustainable approach to plastic waste management.

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Whey valorization from science to hands-on

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Abstract

To ensure sustainable food, promote the circular economy, and achieve SDGs globally, one of the priorities of food processing along the food supply chain was to find suitable ways for the higher valorization of agri-food wastes and by-products. For instance, in dairy industries, one of the most popular food by-products is whey, which contains valuable nutrient compounds with a high potential for valorization in various matrices throughout diverse pathways. The purpose of this work was to point out how science tried to valorize whey into products with added value and our findings about a few case studies in dairy plants about how processors succeed in managing whey streams in factories according to their specific conditions.

A qualitative research methodology was used in two stages. Firstly, the science-advancement technologies for the sustainable use of whey as a dairy by-product were identified in the literature. In the second stage, a comparative analysis regarding whey management was performed in different dairy companies between Romania and Turkey.

The need for waste avoidance of the whey stream generated in the dairy industry is obvious, and a lot of whey-based products and valorization methods were proposed in the literature depending on the whey type. Literature review showed that many steps were made in science to develop emerging technologies and use conventional ones to manage the whey stream in the food industry adequately. Published research highline that whey amino acids or proteins (e.g., b-lacto-globulins, a-lactalbumin, lactoferrin), lactose, and other GOSs, B12 vitamin could be valuable compounds as ingredients for functional food and nutraceutical products. But, even nowadays, the main ways for whey valorization in industrial plants seem to focus on animal feed, whey-based foodstuffs (such as bakery or beverages), or biogas.

A few case studies in dairy plants about compliance with environmental requirements, the ""Zero waste"" goal, and sustainable business growth were performed. Our findings outlined several gaps in managing whey valorization in various companies depending more on production capacity and company type and less on geographical location (Romania vs. Turkey).

Besides ""Zero waste"" desiderate for environmental approach and an improved perception towards consumers, whey management in the agri-food industry envisages economic gains, too. For that reason, the main barriers are insufficient incentives and high-cost investment.

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Examining The Life Cycle Analysis Of Electric Vehicle Batteries: A Review

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Abstract

Life cycle assessment (LCA) is a methodology used to evaluate the environmental impacts associated with the entire life cycle of a product or system. Over the course of electric vehicle (EV) adoption, there has been a progressive increase in the number of LCA studies focusing on EV batteries. However, there is a need for further LCA research of advanced battery technologies and their environmental impacts. This study provides an in-depth review of the life cycle assessment on electric vehicle batteries. Relevant papers on LCA studies for EV batteries published in journals from 2019 to 2023 were reviewed. The review explores various aspects of LCA studies conducted on EV batteries, including their manufacturing, use, and end-of-life stages. It examines the methodologies, data sources, and impact categories considered in these assessments. The review highlights the key findings and trends identified across different studies. The study reveals that the environmental impact of EV batteries is primarily influenced by the extraction and processing of raw materials, energy consumption during manufacturing, and end-of-life disposal or recycling processes. The review demonstrates the necessity of greater efforts to address data limitations and system boundaries and to enable meaningful comparisons across individual LCA studies. It also recognizes the significance of future research in areas such as developing sustainable battery materials, manufacturing process improvements, and recycling technology advancements. In conclusion, this study provides valuable insights into the LCA of EV batteries, shedding light on the environmental implications of their life cycle.

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Isolation and characterization of water-extractable immunomodulating polysaccharides from traditional and alternative medicinal plants

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Abstract

Herbs and their byproducts are rich sources of various bioactive compounds with immunomodulating and antioxidant effects. These compounds can be included in functional and dietary foods and drinks to support human health. The present study aimed to investigate the chemical composition, immunomodulatory and antioxidant activities of water-extractable polysaccharide complexes (PSCs) obtained from traditional and alternative medicinal plants. Using a two-fold extraction with boiling water and ethanol precipitation, 42 herbal PSCs were obtained from aerial parts, flowers, fruits, leaves or roots of 34 medicinal plants. After determining more than 50% of the chemical composition of the PSCs, it was found that most of them were rich in pectins. Twenty PSCs expressed a meaningful in vitro complement-fixing activity through the classical and alternative pathways, and in vitro intestinal immunomodulatory activity. The samples showed a higher complement-fixing activity through the alternative pathway, compared to the classical pathway. The in vitro antioxidant activities of the complexes via the ORAC and HORAC methods were in agreement with their total phenolic contents. In compliance with the introduced criteria (bioactivity, yield, wide use), as promising immunologically active PSCs were distinguished these from *Urtica dioica L., Portulaca oleracea L., Inula helenium L., Symphytum officinale L., Sambucus nigra L., Matricaria chamomilla L., Tilia tomentosa Moench, Calendula officinalis L. and Lavandula angustifolia Mill*. The U. dioica root PSC exhibited the highest in vitro complement-fixing activity via the alternative pathway with IC50= 21.1 µg/mL. It showed the most potent ex vivo intestinal immunomodulatory activity at 100

µg/mL, expressed as a stimulation of Peyer's patch-mediated bone marrow cell proliferation and the production of IL-6 by the Peyer's patch cells. Except for the nettle root, comfrey and elecampane PSCs, where neutral glucans, glucomannans and fructans were mostly presented, the other mentioned samples contained predominantly pectins. The results of the screening study confirmed that by using a continuous boiling water extraction can be obtained immunomodulating polysaccharides and co-extracted some phenolic antioxidants. The extraction of bioactive PSCs could be also applied to herbal byproducts in order to recover more valuable compounds from them as a new step to reach a zero waste approach in food and essential oil industries.

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Opportunities for recovering resources from municipal wastewater using membrane-based processes – the SIREN project perspective

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Abstract

Wastewater treatment plants consume large amounts of energy and materials to treat wastewater and comply with discharge limits. Current linear economy is not sustainable and needs to transition to a circular economy to utilize resources longer and minimize environmental impacts. In the water sector, transition to the circular economy focuses on promoting the reuse, recycling, and recovery of water resources. Despite the efforts, rethinking of the current wastewater treatment paradigm is needed and wastewater should be regarded as a pool of resources with the potential for recovery and generation of valuable products. Among different methods, membrane separation processes have a potential to support the recovery/generation of the products and transitions to circular economy.

The SIREN project aims to integrate innovative processes, including membrane based, into the common wastewater treatment system to significantly enhance the recovery of resources and the generation of valuable products and thereby including the wastewater sector in the circular economy.

The resources are recovered using different membrane processes in three main approaches, including water reuse, energy generation, and nutrient recycling, collectively termed the water-energy-nutrients nexus. For the water, reclamation includes improvement of the water quality by using MF, UF, NF and/or RO in a fit-for-purpose approach and identification of membrane filtration processes suitable for tailoring the water quality to the needs of the specific reuse applications/end-users. For the energy, hydrogen gas generation using a two-cell microbial electrolysis cell (MEC) with and without gel-entrapped bioanodes has been carried out. As part of the project, the most promising combination of options to produce pure hydrogen gas by MEC directly from the organic matter present in the raw wastewater and in partially digested sewage sludge is being identified. For the nutrients, nitrogen harvesting from ammonium-rich reject water of sludge treatment line is combined with concentration of ammonium carbonate using nanofiltration after NH_3 steam-stripping and condensation with CO_2 to facilitate recovery and produce a nitrogen-containing fertilizer product.

The outlook on simultaneous recovery of energy, nutrients and water from municipal wastewater using membrane-based processes will be presented. Besides the opportunities for recovering resources, the new challenges and concerns will also be highlighted.

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Development of a novel rotary disk bioreactor for sustainable bacterial cellulose production using waste derived from the food industry

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Abstract

Bacterial cellulose (BC) is a versatile biopolymer with unique physicochemical properties and diverse applications in food and biomedicine sectors. Upscale of BC production has been primarily studied in static tray bioreactors, as stirred tank bioreactors result in decreased yield. Therefore, innovative bioreactor approaches combined with effective bacterial strains could sustain BC production. In this study, a bench scale rotary disk bioreactor was designed and evaluated for BC production using a newly isolated *Komagataeibacter rhaeticus* strain. Increasing levels of disk submersion (60%, 70%, 80%) and disk rotation speed (5, 10, 15 RPM) led to statistically significant differences on BC production. Under the optimal conditions (70% submersion and 10RPM) the thickness of BC attached to the disk was determined equal to 13.5 mm with BC yield of 320 mg per disk. Mechanically etched disks significantly increased BC yield per disk and the thickness of BC attached to the disks by 41% and 84% respectively, compared to the smooth disks. The fermentation efficiency was further improved when enzymatic hydrolysates derived from food industry side-streams (bakery waste) were applied. BC samples showed enhanced thermal profile, surface charge values while water holding capacity varied within 98-126 g water/g dry BC. The dynamic light scattering analyses showed size distribution within the while FTIR spectra revealed the characteristic bands attributed to cellulose. This study demonstrated a novel bioreactor approach for efficient upscaling of BC production and simultaneous food waste valorization using a newly isolated bacterium.

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A Novel Digester Configuration for Simultaneous Biogas Production and Ammonia Recover

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Abstract

In this study, the effect of side stream vacuum treatment on methane production in daily-fed, completely stirred anaerobic digesters was investigated. The purpose of the process is to reduce the ammonia content in the digester by applying a vacuum to digestate on a recirculation line, thereby allowing the digester to operate with higher organic loading rates. This practice causes the ammonia concentration in the digester to drop below the inhibition level, thereby allowing producing more biogas per unit reactor volume.

For this purpose, two bench scale glass reactors with an active working volume of 6 L were used. One of the reactors was operated as a control (R-control) and the other as a test reactor (R-test) by sidestream vacuum stripping of ammonia in the recirculation line. Both reactors were operated in parallel for 400 days under mesophilic conditions (36±1 ℃).

In R-test, the total ammonia nitrogen (TAN) concentration was reduced by approximately 36.5% from 4525±95 mg/L to 2872±38 mg/L by side stream vacuum stripping for 45 minutes/day. When 30-min vacuum stripping was applied daily, the TAN concentrations were 3063±12 and 3450±19 mg/L in R-test and R-control, respectively, with a difference of about 11%.

With the 45-min vacuum application, 0.28±0.02 L/g-VS methane yield was obtained in R-test, while 0.20±0.02 L/g-VS methane yield was obtained in R-control. As a result, side-stream vacuum stripping caused 42.7% improvement in methane production in the R-test. When the vacuum was applied for 30 minutes, the increase in methane production in R-test was 12.3%, and 0.26±0.01 and 0.23±0.013 L/g-VS methane yields were obtained in R-test and R-control, respectively.

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Bioaerosols Emissions And Quantitative Health Risk Assessment Belonging To A Landfill Leachate Treatment Plant In Istanbul

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Abstract

Landfill leachate contains a complex mixture of organic matter, ammonia nitrogen, phosphate, heavy metals, sulfide, and other biodegradable and non-biodegradable compounds. It requires extensive treatment in landfill leachate treatment plants before it can be safely discharged into the environment (Raghab et al, 2013). It is hypothesized that bioaerosols, such as bacteria and fungi, may be released into the ambient air during these processes, potentially exposing employees to them. A landfill leachate treatment plant located next to a landfill site in Istanbul, Turkey is selected for this study. The aim of this study is to demonstrate seasonal distribution of bioaerosols generated from this plant quantitatively and evaluate health risk assessment for employees at this plant. In this study, air samples were collected at ten different locations within the whole plant in Autumn 2022, Winter, and Spring 2023. The sampling points included the landfill area, equalization tank, different locations in the bioprocess tanks, ultrafiltration/nanofiltration units, biomethanization units, as well as employee working areas such as workshop, office, toilet, and staff rest room. Meteorological parameters such as relative humidity, temperature, wind velocity and wind direction were recorded from Turkish State Meteorological Service. Air samples were collected using Andersen Cascade Impactor with varying sampling times. Samples were transferred to laboratory within ice bags and incubated to estimate the diversity and the quantification of bacteria and fungi. Bacterial and fungal colonies on petri dishes were counted and CFU values were calculated. In this study a questionnaire was made for 29 employees to evaluate their health conditions and their risk perception about bioaerosols. Results of questionnaire will be analyzed using SPSS Version 16. Bioaeroesol concentrations in terms of bacteria and fungi at this ten sampling points will be compared seasonally. Exposure to bioaerosols will be calculated based on 8 hours of time weighted averages.

Quantitative microbial risk assessment (QMRA) will be used to evaluate the health risks caused by exposure to pathogenic bioaerosols.

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Evaluation of the possible application of humic fractions extracted from the sewage sludge as microbial and plant growth promoters

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Abstract

The suboptimal management and overexploitation of soil resources have contributed to a significant deterioration in soil quality in recent years. One of the most significant threats related to the progressive degradation of the soil is the decline of its organic matter (OM). Increasing concerns regarding the impact of human activities on soil deterioration arouse interest in searching for approaches to creating a balance in the soil ecosystem by increasing OM content. Due to the ability of humic substances (HSs) to improve the physicochemical properties of soil, enhance physiological and metabolic processes in plants, and increase the abundance of beneficial microorganisms while reducing the number of harmful ones, stabilizing and increasing the stock of such substances in the soil seems a reasonable approach for restoring its quality. Recently, sewage sludge, a by-product of the wastewater treatment process, has begun to be seen as a promising source of HSs. For this reason, the present study focused on evaluating the applicability of humic fractions (HFs) extracted from thickened (TSS) and anaerobically digested sewage sludge (ADSS) as biostimulants of plants and microorganisms. Analyses of the elemental composition and spectroscopic properties of FAs isolated from TSS and ADSS showed no significant differences between their structures. Comparatively HAs isolated from these sewage sludge differed, i.a. in the content of hydrophobic components. Among isolated HSs, particularly HAs had promising fertilizer values (OM of 83% and N:P:K of 5:1:1 for HAs from TSS; OM of 82% and N:P:K of 14:1:1 for HAs from ADSS). Although the effect of isolated HSs was primarily dependent on their concentration and plant species, all obtained HFs showed a positive impact on the growth of radish, mustard, garden crest, vetch, oats, and corn with HAs showing higher activity in this regard than FAs. Interestingly, HFs isolated from TSS showed promising ability to inhibit the growth of selected phytopathogenic fungi, especially *Phomopsis diachenii* (by 24 to 25%), *Fusarium avenaceum* (by 12%), and *Botrytis cinerea* (by 7 to 25%). The conducted study showed that especially HFs isolated from ADSS positively influenced the overall

microbial activity (by 11 to 33%) in forest soil, poor in OM. Despite the type and dose of HFs introduced into this soil, a similar tendency in the abundance of microbial nitrogen-functional genes (amoA, nxrA, nirS, and nirK) was observed in this environment.

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Long-term effects of microplastics polymers on Anammox process

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Abstract

Microplastics refer to plastic particles with an average size of less than 5 mm and classified as man-made pollutants due to their presence in nature (Lambert and Wagner, 2016). Current studies show that wastewater treatment plants can remove 95% of microplastics found in raw wastewater (Mintenig et al., 2017) on average. It is predicted that the amount of microplastics in sewage sludge will increase in parallel with the increase in plastic production and use in the world (Li et al., 2020). For this reason, it is important to investigate the effects of the presence of microplastics, especially in the sludge units located in the side stream units.

The Anammox process is a promising technology for the treatment of nitrogen under anoxic conditions. Many full-scale Anammox processes are used around the world to serve to reduce the nitrogen load created by side-stream processes. Anammox bacteria have a very low growth rate and are easily affected by environmental conditions. Long-term effects of microplastics polymers of various kinds and sizes on Anammox process were examined in lab-scale sequencing batch reactors in terms of nitrogen removal efficiencies.

Five semi-continuous synthetic-feed anammox reactors (plus one control reactor) were operated in parallel to observe the effects of microplastic polymers on anammox activity. Reactors were operated for approximately 250 days to test the response of anammox process to increasing microplastics concentrations. The impact of microplastic polymers in the range of 50 to 500 mg/L was not different as there was only slight decrease in the nitrogen removal efficiencies among the means of each microplastics concentration within this range. Additionally, the type of microplastics polymer (polypropylene, nylon, polyethylene) did not have a significant impact on nitrogen removal efficiencies. The ongoing reactors will be exposed to higher microplastics concentrations to see the possible inhibition threshold of each polymer type.

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Examination of Waste Management Approaches of Hazelnut Enterprises Operating in the Food Industry in Giresun Province

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Abstract

Hazelnut, which is an agriculturally important product for the food sector and human health, has a production area of over 1 million hectares worldwide as of 2022. Türkiye ranks first in terms of hazelnut production area in the world with 734,000 hectares. Türkiye, which is a leader in global hazelnut production and trade, has a significant share of 70% in total hazelnut production. Therefore, hazelnut is a strategic agricultural product for Türkiye economically. The Black Sea Region, particularly the province of Giresun, is the most intensive region for hazelnut production in Türkiye, ranking fourth among the provinces with the highest hazelnut cultivation with a production of 83,000 tons. According to the data of the 'Black Sea Hazelnut and Products Exporters Association', there are 827 hazelnut processing facilities in Türkiye, 107 in Giresun province, and 54 in Giresun Center. Out of the facilities located in Giresun Center, 16 are engaged in the food industry. In terms of sustainable food production, it is necessary to implement necessary corrective and preventive actions at every stage of the food supply chain, prevent food waste, and increase awareness on environmental and food safety issues. Additionally, the development of alternative methods for the recovery of agricultural waste generated during the food production process is crucial for sustainable food production. The necessity of developing proper waste management strategies has become increasingly important in today's world, where climate change and environmentally friendly practices are gaining more significance. This study aims to examine the waste management approaches of hazelnut processing facilities located in Giresun Center and engaged in the food industry by conducting a complete count method and analyzing their waste practices. The data will be obtained through surveys and observations conducted at the facilities. The collected data will be analyzed and interpreted using the SPSS software package. Accordingly, the waste management practices of hazelnut facilities will be individually investigated, and solution proposals for the required practices in waste management will be developed. In the literature review conducted, no studies specifically related to waste management in hazelnut production were found. Therefore, it is expected that this study will be guiding for other hazelnut cultivation and processing facilities.

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Wine distillery effluents valorization to produce bacterial cellulose and effect of phenolic compounds on the fermentation efficiency

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Abstract

Production and designing of natural biomaterials for multivarious applications have become an emerging sector of materials science, spearheaded by sustainability and renewability. Bacterial cellulose (BC) is an exceptional biopolymer that is produced from acetic acid bacteria. BC is extra pure and it presents unique structural and thermomechanical properties. The liquid streams from the wine distillation process called wine distillery effluents (WDE) are toxic for terrestrial and water bodies due to high chemical and biochemical oxygen demand, heavy metals, dark color and phenolic compounds. In this study, WDE supplemented with biodiesel-derived glycerol were valorized as the fermentation media for BC production with the strain *Komagataeibacter rhaeticus*. The fermentation efficiency in terms of BC concentration, yield and productivity was significantly affected by the WDE percentage (0%, 25%, 50%, 100%) and the initial glycerol concentration (20-45 g/L). Under the optimal conditions of 100% WDE and ≈30 g/L glycerol, the maximum BC production of 9.6 g/L was achieved with a productivity of 0.96 g/L/day and 55.7 g water/g dry BC. The FTIR spectra of BC samples showed typical cellulose vibration bands, while dynamic light scattering analysis presented polydispersity within the nanoscale. BC samples demonstrated enhanced thermal profile and surface charge values. This study demonstrated a circular-low-carbon approach to valorize major waste streams from the winemaking and the biodiesel industry, and their proper formulation to produce a generic fermentation medium that can sustain the production of sustainable, biocompatible, renewable and biodegradable polymers such as BC.

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International Sustainable Resource Recovery Strategies Towards Zero Waste (FULLRECO4US) Conference
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Valorization of peach by-products employing ultrasound-assisted extraction and cold plasma treatment

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Abstract

Waste and by-products management, including their valorization for the recovery of bioactive and functional compounds, is a major topic of interest in the food industry. In addition, the shifting trend of consumers towards more natural products has led scientists to search for more natural food compounds. To this respect, the aim of the present study was the recovery of phenolic compounds from peach (*Prunus persica L.*) by-products, more specifically peach peels, employing Green Chemistry techniques. The peach industry is one of the world's largest fruit industries and produces significant amounts of by-products, such as peels and kernels, that are considered a great resource of natural bioactive compounds. Employing proper processing and extraction methods peach peels can be valorized and industrialized into products with high added value.

The recovery of phenolic compounds from peach peels was performed with ultrasound-assisted extraction (UAE) and optimized through response surface methodology (RSM) using a central composite design (CCD). The extractions were performed at 50% amplitude and the temperature was kept < 35 °C using an ice bath. The independent factors tested and optimized were the ethanol concentration in the solvent, the extraction duration, the solvent: solid ratio, and the pulse duration. Total phenolic content (Folin-Ciocalteu assay), total flavonoid content (aluminum chloride assay), antioxidant activity (DPPH and ABTS radical scavenging activity assays) and chlorogenic acid concentration (HPLC-DAD) were determined in the extracts. In addition, one-factor optimization was performed regarding the effect of cold atmospheric plasma treatment on the recovery of phenolic compounds from peach peels in terms of treatment duration, thickness of the material and material-cold plasma distance.

Based on the results, the optimized extraction conditions were determined at 17 min, 53% v/v ethanol, 70: 1 v/w solvent: solid ratio and pulse duration 0.9 on – 0.1 off. In addition, the duration of cold atmospheric plasma treatment affected the recovery of phenolic compounds from peach peels. The present study highlights the potential of peach by-products valorization and as well as their possible future application as natural additives (e.g., antioxidants) in functional food products."

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Valorization of Pomegranate Peel Wastes Through Extraction and Enrichment of Tannic Compounds

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Abstract

Pomegranate (*Punica granatum L.*) is a fruit that has been used since ancient times to treatment of various diseases such as ulcers, dysentery, and diarrhea. Turkey is one of the leading countries in the world in pomegranate production. Increasing processing of pomegranate fruit results in generation of pomegranate peel (PP). PP is rich in bioactive compounds, predominantly ellagitannins, which are a group of phenolic compounds with well- established biological activities. Ellagic acids are obtained by the hydrolysis of ellagitannins. However, bioavailability of ellagitannins and ellagic acid is quite limited. These compounds are metabolized by the gut microbiota to form different bioactive molecules such as urolithins A, B,C, and D, which are more easily absorbed than the precursor polyphenols. In this work, PP was first extracted through solvent extraction with a solid/-liquid ratio of 1/:5 where water was the extraction solvent. After that, column packed with XAD-16 resin was used for the enrichment of tannins. The tannin fractions were collected using methanol. Then, methanol was evaporated at 40°C using a rotary evaporator, and the extracts rich in tannins were lyophilized for further use. To ensure the tannin content in both PP extract and XAD-16 enriched extracts, thin-layer chromatography (TLC) was performed through the tannin staining method, in which. Chloroform/: Methanol/: Acetic Acid (6.5/:2.5/:1) was used as mobile phase. Moreover, tannin content in the extracts was determined using a UV spectrophotometer via the vanillin-HCl method. The sample absorbance readings was recorded at a wavelength of 500 nm, and the tannin content was expressed as equivalent to catechin. As a result of characterization, the extraction yield of PP was found to be 11.09% while tannin contents in both. PP and XAD-16 enriched extracts were determined as 2.89% and 26.13%, respectively. In this study, extraction and further purification of tannic compounds present in the pomegranate peel were performed successfully. Our future studies aim to transform low-bioavailable tannins into urolithins and urolithin derivatives, which have higher bioavailability with enzymatic pathways using microchannel reactors.

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Valorization of waste of silkworm cultivation (Sericulture): Silkworm feces for the production of value-added products

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Abstract

The silkworm (*Bombyx mori*) itself, the silk obtained from its cocoon, and by-products such as sericin and silkworm waste are used in textiles, biotechnology, pharmacology, and cosmetics. Silkworm feces is known to be rich in chlorophyll and is an alternative source of valuable compounds such as chlorophyll, pectin, phytol, carotene, and triacontanol. These compounds can be utilized in the treatment of various diseases such as hepatitis, stomach disorders, leukopenia, and blood cholesterol. Phytol is a precursor for vitamins E and K, carotene is a precursor for vitamin A, and triacontanol is a potent biostimulant. The aim of this study was to extract chlorophyll (chlorophyll a and b) and chlorophyll degradation products (pheophytin and pheophorbide) from silkworm feces by a two-step extraction process. To achieve this, hexane and acetone treatment was applied to silkworm feces separately and hexane + acetone soxhlet treatment was applied in two stages. In the process of chlorophyll extraction from silkworm feces, non-sterilized and non-ground silkworm waste was soaked in distilled water at a solid-to-liquid ratio of 1/3 and left to stand overnight. In the first stage of extraction, the water-soaked silkworm feces was subjected to a Soxhlet extraction with hexane at a solid-to-liquid ratio of 1/30, resulting in the extraction of lipids and lipid-soluble compounds. In the second stage, a Soxhlet extraction with acetone (1/30) was carried out to extract chlorophyll and its derivatives. Following the two-stage hexane+acetone extraction, the results showed the following yields per gram of dry feces: 8.14 ± 0.12 mg total chlorophyll (a+b), 6.83 ± 0.48 mg chlorophyll a, 1.31 ± 0.44 mg chlorophyll b, 1.27 ± 0.29 mg carotenoids, 5.55 ± 0.60 mg pheophytin, and 6.63 ± 0.18 mg pheophorbide. The experiments conducted revealed that soaking the feces in water increased the effectiveness of the extraction process. The extraction of lipid-soluble components present in silkworm feces was achieved through hexane extraction. The removal of lipids and waxes enhanced the efficiency of chlorophyll extraction. It was observed that in the two-stage hexane+acetone extraction, the yield of chlorophyll obtained increased by 27% in terms of mg chlorophyll per gram of feces compared to single-stage acetone extraction. We can conclude that silkworm feces regarded as a waste of silkworm cultivation (Sericulture) can be valorized efficiently for the production of value-added products.

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Valorisation of ultra-low calorific value biogas using plasma-assisted combustion

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Abstract

Methane has at least 25 times more impact on climate change than CO_2. Around three-quarters of atmospheric methane pollution is produced by landfills and livestock. The rest are related to anthropogenic activity, i.e., industry, etc. Due to the dependence of natural biological degradation processes on seasonal and daily conditions, the emitted CH_4 concentrations from these sources are unstable. In general, if biogas contains less than 30% of CH_4 content, it is considered incombustible because of the low calorific value and emitted into the atmosphere. Previous studies showed that the unique design of a small swirl gas burner assisted with gliding arc plasma could increase the calorific value of biogas approximately four times and maintain stable combustion. The authors conducted complex research on the combustion of low calorific value biogas (CH_4/CO_2) mixtures at different air excesses, oxidising agent composition (O_2/N_2 - O_2/Ar) and the influence of plasma assistance. The spectrometric characteristics of the flame (luminescence wavelengths) at different flame heights were analysed simultaneously by determining the composition of combustion gaseous products (O2, CO, NOx, NO, and NO2). Plasma-assisted combustion with nitrogen-containing air generates high intensities of active radicals, i.e., OH*, O*, NH*, and C2* excitation spectra peaks concentrated near plasma. It was investigated that plasma assistance, air excess and composition significantly influence the formation of radicals and the composition of combustion products. It was proven that the combustion of biogas containing less than 30% CH4 can be used for energy production under plasma-assisted combustion conditions.

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Biorefining platform for the cascade recovery of high value ingredients from the small fruit pomace

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Abstract

Many small fruit species (berries) accumulate high amounts of bioactive constituents. Many berries are highly valued for their unique flavor and are consumed both as fresh and processed foods, while some of them are suitable only for processing due to their unacceptable sensory properties. Berry processing generates large amounts of by-products, which may be used for other purposes or discarded as a waste. Nowadays still large fractions of small fruit processing by-products, e.g. juice pressing residues (pomace) are used rather inefficiently causing the loss of valuable nutrients. Therefore, the interest in valorisation of berry processing by-products is increasing both among the scientists and producers.

This study reports the advances in the development of effective biorefining schemes for the recovery of bioactive phytochemicals and other valuable nutrients from various berry pomace, namely black currant, black chokeberry, raspberry, sea-buckthorn, blackberry, blueberry, bilberry, lingonberry, cranberry, guelder-rose berry, elderberry, sour cherry, rowanberry. The following important aspects were considered in developing 'zero waste' biorefining processes: (1) application of food and environment friendly ('green') extraction and fractionation methods; (2) exhaustive recovery of health beneficial constituents; (3) flexibility in terms of economic and technological upscaling issues; (4) applicability. Considering all these aspects the following groups of valuable ingredients have been obtained from different berry pomace and characterized using various analytical techniques: (1) polyunsaturated fatty acid and nonpolar micro-constituent-rich lipophilic substances isolated under optimized super/subcritical CO_2 extraction and fractionation parameters; (2) defatted antioxidant dietary fiber; (3) polyphenolic antioxidant-rich extracts isolated with pressurized green solvents; (4) the products (dietary fiber, proteinaceous substances) isolated via enzyme (cellulolytic, xylanolytic, proteolytic) and ultrasound assisted extraction and fractionation. Depending on the application goals as well as economic and technological feasibility biorefining scheme may consist of one and more steps, which produce different number of functional ingredients. For instance, the simplest process consists of supercritical CO_2 extraction, which results in 2 functional ingredients, namely lipophilic extract and residue containing polyphenolics, proteins, carbohydrates and minerals.

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Recovery of humic substances from the reject water of digested sewage sludge processing using selected mineral adsorbents

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Abstract

In recent years, byproducts from the wastewater treatment process have begun to be seen as promising sources of humic substances (HSs). Such substances may be recovered in large quantities from wastewater, sewage sludge (SS), and reject water (RW) originating from its processing. In comparison to non-renewable resources of HSs, RWs possess several obvious advantages, including their renewability and large reserves as well as the broad distribution of HSs and the abundance of their varieties. Among various methods applied for the elimination of HSs from aqueous solutions, the adsorption technique is considered to be the extremely promising one, since it is effective even at relatively low concentrations of HSs and with the use of appropriate adsorbents allows for the recovery of such compounds and their reuse, e.g. as soil additives and/or plant growth promoters. Therefore, the presented research has focused on the selection of effective adsorbents of HSs aimed at the removal of these substances from RWs on the basis of model humic compounds (MHCs) used as their surrogates. The obtained results revealed that among twenty-five materials surveyed in terms of their capacity to sorb HSs, opoka (OP) and autoclaved aerated concrete (AAC) constituted the most effective adsorbents of such substances. Further research indicated that the adsorption of HSs on OP may follow Temkin and Langmuir isotherms, while adsorption of such compounds on AAC follows either Temkin, Freundlich, or Langmuir isotherms. The data obtained for the variation of concentration of HSs along the adsorption time onto all selected adsorbents showed that this process in aqueous solution follows a pseudo-second-order (PSO) kinetics. The ability of selected mineral materials to remove and recover HSs present in raw RW (RWR) was further investigated. Verification of the adsorption capacity of OP and ACC towards HSs present in RWR revealed that they were characterized by promising efficiency of their removal at the level of 55%. It was also found that approximately 45 mg of orthophosphates were simultaneously adsorbed with 200 mg of HSs on 1 g of both OP and ACC surfaces during the adsorption process carried out in RWR. The influence of OP and ACC with HSs recovered from RWR on the key life processes of selected plants was verified subsequently in hydroponic cultivations, which made it possible to determine the plant growth-stimulating doses of both prepared materials.

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Transcriptional responses of Saccharomyces cerevisiae to environmental stresses during bioethanol production using biochar-based biocatalysts

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Abstract

Although Saccharomyces cerevisiae is the industrial workhorse of bioethanol production, the strain encounters a plethora of stress conditions during fermentation including high temperature, nitrogen limitation, osmotic stress from substrate sugars and ethanol inhibition. However, biochar-based biocatalysts (BBB) enhance the production of renewable energy from biowaste, mitigating the environmental effects from food waste disposal while improving the sustainability of energy systems. This study aimed to test the efficiency of BBB in ethanol production under inhibitory bioprocess conditions.

Biochar was obtained via conventional pyrolysis of pistachio shells (Pistachia vera) at 500 °C and it was used for the preparation of the biocatalyst via immobilization of S. cerevisiae as previously described. The biocatalyst prepared was employed in bioethanol production experiments at the elevated temperature of 39 °C, while q-PCR analysis was conducted to determine mRNA expression from genes HSF1 and TPS1 known to impose instrumental effect in coping with heat shock stress. The expression levels of HSP104 and HSP12 were additionally investigated upon exposure of yeast cells to high bioethanol contents, while the intracellular proline level was determined to assess the protective effect of the biomolecule against various stresses, including heat-shock and elevated bioethanol concentration.

Bioethanol fermentations of both freely suspended and supported cells of S. cerevisiae were conducted at 30 °C and 39 °C. Supported cells reached final concentration of 41 g L^{-1}, while the suspended culture yielded 34 g L^{-1}. Faster kinetics were obtained using BBB producing 30.9 g L^{-1} of bioethanol following 4 h of incubation as opposed to free cells that formed only 8 g L^{-1}. The mRNA expression levels monitored confirmed the stress protective role of BBB against heat stress, given that relative expression of HSF1 was significantly higher in suspended cells as opposed to BBB at 39 °C, demonstrating that the heat-shock response pathway was not triggered following attachment of the yeast on the biomaterial. Moreover, the BBB system could efficiently sustain fermentations conducted under 90 g L^{-1} initial bioethanol content, which resulted in complete failure of conventional fermentations.

The current work demonstrates that biochar-based biocatalysts can protect cells from heat shock stress and elevated bioethanol contents improving the performance of the fermentation process.

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Elemental assessment of *Ficus Carica L.* fruit peel biomass towards their potential valorization for the preparation of value-added food products

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Abstract

Ficus carica L. (fig fruit) belongs to the botanical family moraceae and it is among the most important fruit species in the Mediterranean area due to its valuable composition. Typically, figs are peeled, and the flesh of the fruit is eaten, while the peel is discarded. The nutrient content (i.e., including polyphenols, dietary fiber, proteins, lipids, vitamins, organic acids, and metals) of fruits can vary significantly between flesh and peel. Among them, metals are an important family of fruit constituents that can determine the quality of the final product. In this context, the elemental assessment of the flesh and the peel of figs can play a detrimental role for their future consideration for valorization purposes since the fruit and vegetable industries produce high volumes of waste. Due to their beneficial constituents, fruits can be valorized into value-added products including nutritional foods. In this study, the elemental content of eight different varieties (i.e., Black mission, Petrelli, Palazzo, Petra, Panino, 3030, Vasilicato, Panache and Turko nero) of figs cultivated in Greece were analyzed aiming to assess the elemental composition (i.e., Ag, Al, B, Bi, Ba, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Ni, Pb, Zn) of the flesh and the skin of the fruit. Autoclave acidic digestion was employed for sample preparation and the determination of the metals was performed by an optimized and validated inductively coupled plasma-atomic emission spectrometric (ICP-AES) method, followed by advanced chemometrics.

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Integration of anaerobic digestion and electrodialysis for methane yield promotion and ammonium in-situ recovery

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Abstract

Anaerobic digestion (AD), which converts organic matter in organic wastes (animal manure, agricultural by-products, organic wastes, etc.) to biogas, provides a clean route to produce renewable bioenergy, thus playing a critical role in the climate-neutral economy. Adoption and application of AD can be improved by addressing two challenges: one is methane (CH_4) production inhibition by high ammonium (NH_4^+) concentration and the other is digestate disposal (Choudhury et al., 2022). This study aims to develop a novel AD technology for high CH_4 production efficiency by in-situ NH_4^+ recovery with electrodialysis technology (ED). The feasibility of ED in NH_4^+ recovery from digestate has been justified with our preliminary study (Meng et al., 2022; Shi et al., 2019). Thus, this study will investigate the feasibility of the proposed ED-integrated AD system (ADED) for NH_4^+ in-situ recovery and methane yield promotion. The proposed ADED technology could bring the following advantages: (1) ED utilisation can recover NH_4^+ from the AD digesters as the fertiliser; (2) NH_4^+ recovery can promote the CH_4 yield and improve the digesters' loading rates and economic viability; and (3) NH_4^+ recovery can avoid its volatilisation in digestate land spreading.

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Exploring the Potential of Biorefineries: Conversion of Olive Processing Industry Waste into Polyphenols, Algal Biomass, and Lipids

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Abstract

Olive pomace (OP) comprises a semi-solid residue obtained in large quantities following olive oil extraction, while table olive processing wastewater (TOPW) is generated by the processing of olives required to become edible, emitted in rapidly increasing volumes in recent years. In the current work, a biorefinery was developed employing Isochrysis galbana and Scenedesmus obliquus for the manufacture of polyphenols, lipids and algal biomass, using OP and TOPW. High biomass and lipid levels could be potentially formed during the cultivation of the aforementioned microalgal strains using OP and TOPW, given that the application of the specific microalgae strains under 1% glucose resulted in biomass productivity that reached 0.13 and 0.06 g/L/d for *S. obliquus* and *I. galbana* respectively.

OP was obtained by a two-phase system while TOPW was customly prepared using 1.5 kg of black olives and 3 kg of water or brine. Different operational parameters were investigated for the fractionation of OP into its main constituents, including the removal of residual oil, water extraction (WE), dilute acid (DA) pretreatment and enzyme hydrolysis (EH). Moreover, four different polymeric resins (XAD16N, XAD7HP, PAD900, XAD4) were evaluated for their capacity to recover the phenolic content of TOPW and OP extracts.

WE of defatted OP (100 °C, 15 min, 10% solids) resulted in the recovery of 9.4% reducing sugars and 1.1% polyphenols. Moreover, DA hydrolysis (1% w/v H2SO4, 135 °C, 60 min, 10% solids) achieved 92% hemicellulose removal, while EH (15 FPU Cellic® CTec 2 g-1substrate, 24 h) achieved 54% of cellulose hydrolysis. Application of XAD16N and PAD900 exhibited the highest overall polyphenols recovery, that reached 79.5% and 58.0% for TOPW and OP extracts respectively. Cultivation of S. obliquus employing detoxified effluents resulted in 0.19 g/L/d and 61.4 mg/L/d biomass and lipid productivity, while *I. galbana* produced 0.032 g/L/d and 8.4 mg/L/d, respectively. *I. galbana* accumulated high docosahexaenoic acid content, which reached 8.4-9.5 mg/g of ash-free dry weight.

The biorefinery proposed enabled production of high polyphenol contents, while algal fermentations confirmed that the biowaste applied could serve as advanced feedstocks for polyunsaturated fatty acids manufacture in microalgal biorefineries. Future work will focus on enhancing the lipid content generated aiming to maximize process effectiveness.

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Citrus processing waste-based biorefinery for bioactive compounds and bacterial cellulose production

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Abstract

The worldwide industrial generation of citrus peel waste exceeds 23 x 10^6 t per year and mainly consists of peels, pulp, seeds and segment membranes. An additional burden of citrus processing industries (CPIs) concerns the significant amounts of wastewater disposed, which constitute up to 17 m3 per t of processed fruit, depending on the process and the water management in the production plant. Citrus processing wastewater (CPWW) emitted from relevant industries is characterized by large variability of organic loads, soluble or insoluble compounds, such as sugars, bioactive compounds and organic acids. Bacterial Cellulose (BC) constitutes a biopolymer of significant industrial importance owing to its unique properties including high crystallinity and enhanced mechanical strength. The present work aims to develop a biorefinery exploiting green technologies for manufacture of bioactive compounds (phenolics) and BC using citrus processing waste (CPW).

CPW was characterized in terms of chemical oxygen demand (COD), total sugars (TS), total phenolic content (TPC) and free amino nitrogen (FAN) using standard analytical methods. A green technology has been developed for the recovery of the phenolic content entailed in the liquid fraction of CPW. Different adsorption materials (nonionic resins and biochar) capable of adsorbing polar and non-polar polyphenolic compounds were assessed in batch experiments. Moreover, the desorption capacity of each material was determined using packed columns at different flowrates of the organic solvent. The liquid fraction remained following flavonoids recovery was employed in fermentations using Komagataeibacter sucrofermentans DSM 15973 for BC production under different initial sugar concentrations and nitrogen sources.

CPW constituted 104 g/L COD, 57.3 g/L TS, 1.3 g/L TPC and 98.3 mg/L FAN. Polyphenols adsorption reached 75% using a non-polar resin, while 94% of polyphenols desorption was achieved at an ethanol flowrate of 0.1 L/h. The liquid remaining following application of the adsorption/desorption process was employed as a nutrient-rich feedstock in bacterial fermentations yielding up to 0.26 gBC/gTS. Application of peptone and yeast extract in fermentations maximized biopolymer production as compared to the use

of other nitrogen sources. The present study demonstrated the development of an innovative biorefinery strategy for the manufacture of bioactive compounds and BC exploiting the waste streams emitted from CPIs.

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An approach to matchmaking in waste-to-energy towards bioenergy

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Abstract

The global trends in biofuel production point to more than 2 million barrels of oil-equivalent per day in a near future, revealing worldwide increasing needs to explore new renewable energy sources [1]. With the recent global energetic crisis and the increasing demand for energy related assets, the application of Waste-to-Energy (WtE) techniques to produce biofuels has been considered a promising integrated approach. This is mainly due to the efficiency and flexibility of these techniques towards various types of feedstock, also supporting circular economy principles [2, 3].

Biomass residues are excellent candidates for WtE conversions as their availability from the agricultural/industrial sectors constitutes a relevant environmental challenge [4]. Thus, using them as feedstock for biofuel production would simultaneously serve two interesting purposes: contributing to useful waste management strategies dedicated to this sort of waste streams, while producing a greener alternative to fossil fuels, under an environment-friendly framework, towards sustainability goals.

This work proposes a review discussing recent literature on pre-processing procedures assisting biomass waste thermal conversion, to promote the production of biofuels and other commodities. Pre-processing methods enable cleaner and proficient conversions, once a more homogeneous, dry, suitable and consistent feedstock is achieved, lessening the impacts of the overexploitation of natural resources. Key thermal conversion techniques were summarized and the relation among these and the most convenient pre-treatment options was identified for each biomass type. Knowledge gaps and future opportunities to enhance circularity in the field were also detected.

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Manufacturing and Characterisation of Polymeric Nanocomposite Membranes for Water Treatment Applications

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Abstract

Polymeric membranes are thin, porous films composed of polymers and utilised in separation processes, such as wastewater treatment. The manufacturing steps consist of polymer preparation, membrane formation, curing, and modification. Since polymeric membranes provide high separation efficiency, low energy consumption, and a compact footprint, they are extensively used in reverse osmosis (RO), ultrafiltration (UF), nanofiltration (NF), and microfiltration (MF). They remove contaminants such as suspended solids, bacteria, viruses, and organic compounds from wastewater. Polymeric nanocomposite membranes are a type of membrane that incorporates nanoscale fillers, such as inorganic nanoparticles, nanotubes, or clays, into the polymer matrix. This process enhances the membrane's mechanical, thermal, and transport properties. Due to their improved performance and selectivity, polymeric nanocomposite membranes have great potential applications in water treatment, gas separation, and biotechnology. Numerical methods are often chosen to model the mechanical properties of composite materials. In various studies, the Mori-Tanaka homogenisation method and finite element analysis have been employed. Numerical methods provide fast and accurate results for the design and optimisation of composite membranes. This study aims to manufacture and assess the mechanical properties of polyethersulfone (PES)-based halloysite nanotube (HNT) reinforced membranes with different mass fractions, both experimentally and through numerical simulations. The membranes are manufactured with the phase inversion method and subjected to tensile testing under quasi-static conditions in order to determine their mechanical properties. Within this study's scope, the mechanical properties of HNT-reinforced polyethersulfone membranes with varying mass fractions of HNT reinforcement and the unreinforced membrane are determined with tensile tests and the results are compared. Furthermore, the Mori-Tanaka homogenisation method and finite element analysis are applied to numerically analyse and compare the manufactured composite membranes' mechanical properties. These analyses are

conducted on each membrane's representative volume elements (RVEs). The effect of HNT reinforcement in the polyethersulfone matrix is completely figured out.

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From waste to protein through gas-based mixed microbial culture fermentation

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Abstract

Following innovative circular bioeconomy practices, multiple waste and residues are currently being evaluated as potential substrates for the synthesis of alternative protein sources such as microbial protein (MP), also known as single cell protein. Nevertheless, the potentially contaminated, complex and variable matrix of agri-food waste and residues restricts the number of suitable feedstocks. To overcome this challenge, the conversion of organic waste and residues into gaseous substrates through e.g., anaerobic digestion, pyrolysis and gasification, could enable disconnecting the final MP product from the contaminated waste feedstock, further improving the performances of the process by guaranteeing a stable gaseous substrate composition and a selective environment for MP production. Despite these advantages, the use of recovered gas sources poses severe challenges due to the presence of potentially inhibiting or toxic components such as carbon monoxide (CO) and hydrogen sulfide (H_2S). To this end, the use of mixed microbial cultures, as opposed to the conventionally employed mono-culture systems, could offer a series of unexpected advantages linked to the synergistic and beneficial interaction of different microbial actors. In this study, the experimental evidences obtained by combining microbial groups having different metabolisms for the upgrade of selected recovered gas substrates are presented and critically evaluated. More specifically, the performances of selected and adapted mixed microbial cultures during the fermentation of sulfide-rich biogas, CO- and sulfide-rich syngas were assessed. Sulfide-rich biogas (up to 4000 ppm of H_2S) was successfully converted into MP biomass by means of a naturally enriched methane-oxidizing bacteria (MOB) and sulfur-oxidizing bacteria culture, reaching protein concentrations as high as 73% and outperforming conventional mono-culture MOB processes. CO- and sulfide-rich syngas (up to 40% of CO and 2000 ppm of H_2S) was instead successfully converted into MP (65% of protein) by means of a mixed microbial culture of hydrogen-oxidizing bacteria (HOB), demonstrating their higher resistance to potentially toxic gases with respect to single and pure HOB cultures. The presented results support the future development of wider and more effective circular valorisation pathways of overabundant waste and residues, potentially triggering the onset of novel avenues in waste to protein conversion approaches.

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RECYCLING AND WASTE RECOVERY IN BOSNIA AND HERZEGOVINA

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Abstract

Recycling is the process of extracting raw materials or materials from waste and its reuse. The recycling process includes collecting waste, extracting useful materials, processing and making new products from recycled materials. Due to its ever-increasing amount and harm to the environment, waste is considered one of the most significant environmental problems of the modern economic development in Bosnia and Herzegovina. A large part of the needs is created artificially and the question is whether we really need so many different products that, after use, will become waste. The aim of this work is to point out the enormous problems with recycling and valorization of waste in Bosnia and Herzegovina.

The Law on Waste Management of Bosnia and Herzegovina is the legal framework for the establishment of a sustainable management system for all types of waste, and it regulates basic principles, categories, types and lists of waste, waste treatment procedures, planning and division of responsibilities between entities in Bosnia and Herzegovina. Conditions are slowly being created in Bosnia and Herzegovina for the introduction of a complete waste management system. The current state is best described by the scenes from our Bosnian rivers - once clean and beautiful, today they are filled with various garbage. Products made of different types of plastic are increasingly present on the market in Bosnia and Herzegovina, mostly seen in the mass use of plastic bags, which can later be seen on public areas, picnic areas and river banks as an ugly sight of human carelessness and irresponsibility. The Industrial and Special Waste Management Strategy in Bosnia and Herzegovina, adopted in 2002, represents a significant move towards the establishment of a waste management system.

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The social assessment of waste-to-energy techniques: critical insights and the way forward

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Abstract

The exponential population growth seen over the last decades has led to a high demand for resources, due to an unparalleled industrial and technological development to serve the population needs. This highlights even more the pre-existing waste management issues and dissimilarities among distinct communities and socioeconomic contexts [1]. Waste-to-energy (WtE) strategies constitute a potential approach to convert residues into energy, when no higher hierarchical approach is viable, according to EU legislation [2]. This is mainly due to the efficiency of these techniques as well as their environmental performance [3]. The recent global energetic crisis and the increasing demand for energy-based assets has served to accentuate the need for this type of dual approach, producing renewable energy and managing wastes at the same time. Sustainability considers the environmental, the economic and the social spheres [4]. As much as the economic and environmental benefits of WtE have been assessed and reported in terms of viability and feasibility of implementation, the evaluation of the social dimension is scarcely seen and, when conducted, it is rather narrow and anarchic [5]. Therefore, comprehensive assessments on the social features of the WtE are still lacking. This work reviewed the relevant literature on the assessment of social aspects within the WtE sector, discussing the main findings and putting forward some strategical ideas aiming to promote a deeper assessment and a higher commitment towards the importance of conducting social-LCA studies. Mapping this particular aspect revealed lack of technical implementation and supporting literature, which justifies the need to promote and conduct social assessments in a standardized and regular fashion, despite the efforts to (individually) assess some parameters or a few set of indicators, as seen so far.

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Polyphenol Recovery from the Rose Processing Wastewater

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Abstract

Rose oil is mainly produced by distillation. After distillation a relatively high temperature waste (rose processing wastewater) remains consisting of distillation water together with the rose flower wastes, rich in non-volatile polyphenols. In this study, polyphenol recovery from the wastewater generated after rose oil production with ceramic membranes was investigated. Three different ceramic membranes with pore sizes of 1 kDa, 15 kDa and 150 kDda were investigated. Rose processing wastewater filtration was conducted with all membranes. At the end of the filtration polyphenol recovery from membrane surface was done by using ethanol. Polyphenols were analysed by using high-performance liquid chromatography (HPLC) in inflow, permeate, and recovery lines of the filtration. The results showed that the ceramic membranes have the potential to provide both good performance in rose processing wastewater treatment and polyphenol recovery from the membrane surface.

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Resource Recovery in Line with Energy Generation at an Agro-Food Industry

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Abstract

Since the number of agro-food industries extensively increased in many countries; effluents from these facilities pose environmental concern also hindering the sustainability of agro-food sector. However, if these effluents are considered as raw materials instead of wastes, some bio-based chemicals, materials, and even fuels could be obtained in a more economic and sustainable way due to their composition rich in proteins, sugars, lipids, along with a number of aromatic and aliphatic hydrocarbons. Among the agro-food products, bulgur is one of the earliest foods in Anatolia which is a wheat product (Triticum spp.) and rich in fibers. Due to its high nutritional quality, bulgur has been consumed in large quantities in Turkey which ranks the fourth place in bulgur production (i.e., 1.5 million tons/yr). However, the most critical issues is high energy and water consumption especially during cooking process where starch gelatinizes and excess water is used. Accordingly, annual wastewater generation could be 1,000,000 tons with high COD (up to 20,000 mg/L). Therefore, anaerobic treatment is one of the most suitable and sustainable options for such high organic loaded effluents. Besides, useful by-products such as biogas and polyhydroxyalkanoates (PHAs) also contribute to reducing energy requirement and carbon footprints, as well as creating environmentally friendly solutions. Hence, the aim of this study is to investigate anaerobic treatability and potential by-products of wastewaters generated from an agro-food industry where bulgur production is carried out. In this scope, the batch assays were conducted at mesophilic condition (35±2°C) using 1 L reactors running with the same inoculum (1:4; v/v). Solids, COD, alkalinity, TKN, TP, and pH were determined while daily biogas generation was monitored. Fermented bulgur wastewater was subjected to additional respirometric tests to evaluate VFA recovery as PHAs in activated sludge systems. The tests were conducted with seed biomass from a fill-and-draw reactor, where the mixed culture biomass was fed with acetate (SRT=12 d). Biomass with MLVSS of 3000 mg/L and 30 mL of fermented wastewater was fed to batch reactor and nutrient solution was added with 1.07 g nitrification inhibitor to total volume of 2 L in respirometric test. DO and oxygen uptake rates were monitored and samples were taken for COD, VFA and PHA analysis to determine the optimum fermentation time and PHA production efficiency for bulgur wastewater.

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The seasonal changes of heavy metal content in sewage sludge as limiting factor of fertilizer quality on the base of data from WWTPs in Poland

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Abstract

In Europe, half of the amount of sewage sludge from wastewater treatment plants (WWTPs) is used in agriculture, in Poland about 27%, respectively. There are several national law regulations based on the sludge framework directive (86/278/EEC) limiting level of contaminations (mainly heavy metals) when waste is directly used on soil surface. However, novelization of Sludge Directive may restrict or even hinder the agricultural use of sewage sludge. Hence, effective fertilizing products (compost or organic-mineral fertilizers) derived from sewage sludge are good alternative for no-treated waste. There are some crucial factors: organic matter, biogenic elements and toxic compounds. While organic substances and nutrients are usually present in a sufficiently large amount, the content of toxic substances may be influenced by various factors, including the presence of industrial wastewater or size of the treatment plant. The paper presents the results of heavy metals content (Cu, Pb, Ni, Zn, Cr, Cd, Hg) in sewage sludge analysed by certified laboratories, made available by WWTPs from different regions of Poland collected from whole 2021. The analysis of the obtained results was carried out in terms of the possibility of using sewage sludge for agricultural purposes. The obtained results indicated very wide ranges of the content of individual elements in the dry matter of the sludge, including the content of Cu in the range of 0.4 to 784 $mgkg^{-1}$ d.m., Ni from 0.25 to 1281 $mgkg^{-1}$ d.m., Cd from 0.005 to 14.85 $mgkg^{-1}$ d.m., Pb from 0.11 to 306.2 $mgkg^{-1}$ d.m., Hg from < 0.001 to 2.3 $mgkg^{-1}$, Cr from 0.23 to 854 $mgkg^{-1}$ and Zn from 11 to 4669 $mgkg^{-1}$, respectively. It has been shown that Cu, Cd, Pb, Hg and Cr concentrations did not exceed the permissible levels of used for agricultural purposes according to Polish regulations. There were few cases of exceeding the amount of nickel and zinc. It was found that there was no clear correlation between the minimum and maximum heavy metal content and the size of the treatment plant expressed as population equivalent (PE). Moreover, to seasonal changes in the content of heavy metals in sewage sludge, and seasonal variability of the levels of individual elements was also noted. It has been concluded that in spite relatively low level of heavy metals, it may be limiting factor for production high quality stable fertilizers on the base of sewage sludge.

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Integration of anaerobic co-digestion into a sustainable livestock farming system

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Abstract

Anaerobic digestion (AD) of livestock slurry is an effective approach to reduce greenhouse gas (GHG) emissions during slurry management, while generating valuable products such as energy and organic fertilizer, through biomethane and digestate, respectively. Available AD feedstocks in Ireland, where pasture-based livestock systems predominate, include slurry and grass silage. However, there is little information about how AD could be sustainably integrated into livestock farms. The aim of this study was to assess the GHG emissions and nutrient flow balances from a farmland area dedicated to both beef production and providing grass silage for AD. The Grange Dairy Beef Systems Model (GDBSM; Kearney et al., 2022), which includes economic and GHG emissions sub-models from pasture-based beef production systems, was deployed. A 40 GWh biogas plant was assumed, this being considered representative of a commercial scale AD plant, with this plant being supplied with feedstock from a network of 50 ha beef farms. In turn, the digestate generated from the AD plant was assumed to be returned to the beef farms. The proportion of livestock and AD silage area per farm was calculated from the proportion of the total area needed to produce each feedstock (i.e., slurry and grass silage). Red clover and perennial ryegrass (RC/PRG) sward were selected for AD silage as they do not require nitrogen inputs and thus, are more likely to meet European regulatory guidelines for renewable energy generation. Results showed that based on the feedstock produced per farm, a total number of 124 farms, each producing 42.5 ha of livestock (85%) and 7.5 ha of AD silage (15%), would be necessary to meet the AD feedstock demand. All the total digestate produced (79,834 m^3) was returned to the livestock area, thereby saving 59%, 47% and 97% of the nitrogen, phosphorus and potassium requirements, respectively. GHG emissions were reduced by up to 25% when compared to a comparable beef farm which did not receive digestate to meet some of the nutrient requirements. These outcomes enhance our understanding of agricultural feedstock provision and digestate management for agricultural biomethane plants and can guide farmers, the biogas industry and policy-makers in the development of management guidelines.

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Indoor CO_2 As Renewable Carbon Source: Coupling Indoor CO_2 Direct Air Capture To Microbial Electrosyntehsis Technologies

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Abstract

A Carbon dioxide direct air capture (CO_2-DAC) and conversion to chemical feedstocks is a suitable solution to contribute to the replacement of fossil fuels. CO_2-DAC technologies developed so far focused on capturing atmospheric CO_2 from outdoor environments. However, CO_2-DAC from indoor environments, where CO_2 is mildly concentrated, can help to overcome the thermodynamical limitations of CO_2-DAC technologies. Most importantly, removing CO_2 contributes to improving indoor air quality. This work aims to assess the coupling of CO_2-DAC and microbial electrosynthesis (MES) technologies to produce carbon-neutral commodity chemicals, through a theoretical and experimental approach. First a theoretical study was performed simulating the installation of CO_2-DAC technologies in three different scenarios: (i) high school classroom, (ii) office room, and (iii) underground transport cabin. For each scenario, MES cells were designed based on the state-of-art performance parameters reported in the literature for the conversion of CO_2 to biofuels (either methane or ethanol). The produced biofuels were compared as green fuels for heating the environments, assuming an external temperature of 10 ºC and a target temperature of 20 ºC. A preliminary economic analysis was carried out based on the current market price of electric energy to assess the feasibility of this visionary technology. Methane prevailed as the most viable solution, resulting in a substantially lower reactor footprint and power consumption than those calculated for CO_2 conversion to ethanol. It was estimated that the methane produced can be used for heating the indoors at an electricity cost of 4.1-6.1 €/d per room, which is considerably lower if compared to the non-household EU average electricity cost of 180 €/MWh. Secondly, using the information obtained from the theoretical study, an experimental setup coupling a lab scale CO_2-DAC prototype and a MES cell was used to couple the capture of CO_2 from indoor air to produce methane. Through this experimental setup a concentrated stream of CO_2 consisting of 80 % CO_2 and 20 % N_2 was produced and used to feed the MES cell to produce methane at an average production rate of 70 ± 6.56 L CH_4/m^2 d and a composition of 75 ± 7 % CH_4. This

work demonstrated the potential of this novel process to use CO_2 from indoor environments as renewable carbon source.

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Assessment of sewage sludge for nutrient recovery and its accelerated use in agriculture

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Abstract

Up till recently sewage sludge has been regarded as waste with high risks and problematic re-use and due to its considerably lower quantities than solid waste it has been neglected in circular economy targets Furthermore, health and environmental risks have been identified. Nevertheless, constant increase in sludge quantities has been observed globally. In EU the amount of sewage sludge produced per year was 10 million tonnes in 2008, 11.5 million tonnes in 2015 and is expected to approach 13 million tonnes of dry matter (DM) by 2020.

Sludge management is one of the most difficult and challenging tasks of wastewater treatment plants due to its high water content and poor dewaterability and strict regulations for sludge reuse or disposal. To assess the potential use of sludge for high-value biomolecule production, sludge samples from 13 Latvian wastewater treatment plants were collected and their chemical analysis performed. Proteins, lipids, carbohydrates and cellulose were quantified in primary, secondary and anaerobically digested sludge. This assessment of Latvian municipal sewage sludge revealed a considerable amount of carbohydrates and proteins present in primary sludge (10.0% dw and 23.9% dw, respectively) as well as in secondary sludge (8.7% dw and 18.5% dw). The evaluation of chemical content aided the process of designing a biorefinery strategy for sewage sludge relevant for Latvian WWTPs. In addition, sludge hygienization methods and direct application for plant growth without stabilization was performed. Biological sludge from municipal sewage system was collected, treated (addition of calcium compounds, thermal treatment, and UV irradiation) and mixed with non-sludge origin soil. Further, peas were grown in the samples and their growth and biomass development recorded

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Microencapsulated saffron floral by-products extracts as functional ingredients for antioxidant fortification of yogurt

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Abstract

Currently, massive amounts of agri-food waste and by-products are generated globally in the agri-food industrial sector. Efforts to valorize them have become of interest to the food industry due to their content of valuable compounds which can be reused as high value-added ingredients. An example is the industrial production of saffron (*Crocus sativus L.*), the most expensive spice in the world. The high costs are because only the dried-up stigmas are used for the spice and the rest of the flower is discarded, being necessary around 230,000 flowers (~60-80 kg, being ~78% tepals) for the production of 1 kg of saffron. Therefore, considering that hundreds of kilograms (~205,000 kg) of saffron arrive to the market each year and the production yields range between 0.02-0.03 kg of dry stigmas per ha, the current production system is generating several hundreds of tons of tepal wastes (~9,500-12,700 tons/year). Recent studies have reported that the utilization of industrially-derived saffron by-products may represent an important source of nutrients such as dietary fiber and bioactive compounds, specially flavanols and anthocyanins, while its reutilization can provide a significant source of income. The present study aimed to determine the effect of adding alginate-based microencapsulated saffron floral by-products extracts (0.5%, 1%), or/and saffron stigmas extracts (0.05%, 0.1%) to homemade yogurts, since the development of innovative dairy products enriched with saffron waste could represent a novel environmentally-friendly technological solution. For this purpose, physical-chemical properties, antioxidant capacity, total phenolic content (TPC), microbiological analysis, color and organic acids and soluble sugars profile were determined at 0, 7, 14 and 21 days of storage at 4 ºC. The results showed that these novel yogurt formulations allowed proper fermentation, being the microbiological profile and physical-chemical parameters not affected by saffron extracts, compared to the control. The incorporation of microencapsulated saffron floral extracts improved the functional properties in terms of TPC and antioxidant properties which remained stable over 21 days of storage. In conclusion, saffron floral by-products-alginate beads could be potential sustainable candidates to be used as functional ingredients improving the nutritional and functional value of yogurts.

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Energy management system application in healthcare: a case study of Serbia

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Abstract

The paper presents the implementation of an energy management system (EnMS) in healthcare institutions, which are characterized by a constant and strict demand for energy. Given the need to manage energy use more effectively in hospitals and healthcare facilities, there is a growing imperative to establish targets aimed at reducing fossil fuel and electricity consumption. An EnMS with a defined energy policy, energy goals, and strategies to achieve those goals provides a system for monitoring energy performance and establishes procedures for continuous improvement in energy performance. The ISO 50001 standard for energy management systems evaluates the energy performance of individual institutions and proposes a management model that was utilized in this study. Given that healthcare institutions are the second highest energy-intensive buildings in the commercial sector, particular attention must be paid to this sector. The findings of this investigation offer scientific insights for national policy enhancement and a well-developed model based on the Plan Do Check Act (PDCA) cycle for EnMS implementation. The aim of the research was to ascertain the present state regarding the adoption of energy management practices in such establishments. In addition, this study underscores the relevance of zero waste and a circular economy approach for healthcare institutions, which could be further explored as a complement to energy management systems. Such practices entail a holistic approach to resource management, where the waste produced during healthcare operations is converted into a valuable resource through recycling and other waste reduction strategies. Furthermore, the adoption of circular economy practices could enhance the sustainability of healthcare facilities, thereby supporting the overall objective of reducing energy consumption and mitigating climate change impacts.

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Conceptual system for sustainable and next-generation wastewater resource recovery facilities

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Abstract

Shifting the concept of municipal wastewater treatment to recover resources is one of the key factors contributing to a sustainable society. A novel concept based on research is proposed to recover four main bio-based products from municipal wastewater while reaching the necessary regulatory standards. The main resource recovery units of the proposed system include upflow anaerobic sludge blanket reactor for the recovery of biogas (as product 1) from mainstream municipal wastewater after primary sedimentation. Sewage sludge is co-fermented with external organic waste such as food waste for volatile fatty acids (VFAs) production as precursors for other bio-based production. A portion of the VFA mixture (product 2) is used as carbon sources in the denitrification step of the nitrification/denitrification process as an alternative for nitrogen removal. The other alternative for nitrogen removal is the partial nitrification/anammx process. The VFA mixture is separated with nanofiltration/reverse osmosis membrane technology into low-carbon VFAs and high-carbon VFAs. Polyhydroxyalkanoate (as product 3) is produced from the low-carbon VFAs. Using membrane contactor-based processes and ion-exchange techniques, high-carbon VFAs are recovered as one-type VFA (pure VFA) and in ester forms (product 4). The nutrient-rich fermented and dewatered biosolid is applied as a fertilizer. The proposed units are seen as individual resource recovery systems as well as a concept of an integrated system. A qualitative environmental assessment of the proposed resource recovery units confirms the positive environmental impacts of the proposed system.

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Filtration and adsorptive properties of biodegradable electrospun polyactic acid and cellulose acetate filters with biomass-derived activated carbon

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Abstract

Air filters are crucial components of a building ventilation system and kitchen hoods that contribute to improving indoor air quality. Activated carbon, thanks to its high specific surface area trap odor particles (Volatile Organic Compounds) and particulate matter (PM_2 and PM_{10}) produced during cooking.

Electrospinning, which is a very simple and low-cost method of synthesis of nanofibers, guarantees excellent filtering performance of the obtained membranes. Compared with conventional air filter media like glass fibers and melt-blown fibers, the electrospinning membranes due to the smaller pores are more efficient for capture various pollutants.

In this paper, eco-friendly PLA (polylactic acid) and Cellulose acetate (CA) with activated carbon (AC) sandwich-like filters were prepared via electrospinning to obtain a high-quality factor (QF) fibrous mat for aerosol particle filtration and VOC adsorption. For this purpose, special attention was paid to the biodegradable and sustainable materials used to produce fine nanofibers. Two different methods of functionalization of the fibers with AC have been used. These methods are air spraying and electro-spraying. Several configurations of the final membranes have been investigated. Various process parameters such as spinning concentration, activated carbon loading, spinning volume of the membranes, voltage and flow rate were tested in terms of air filtration performance and fiber morphology. Physio-chemical properties and morphology of obtained filters were characterized by TG, SEM, FTIR, N_2 adsorption-desorption isotherm analysis. Filtering efficiency and adsorption properties were evaluated in real-scale room by measuring the filter penetration of new-synthesized and commercial filters, against neutralized aerosol particles (2% NaCl) and VOC (Methyl Ethyl Ketone). Regeneration methods were studied. Our results indicate that proposed hybrid membranes, would be promising materials for highly efficient and sustainable air filters for home appliance systems.

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Amazing nutrients recovery and metal removal during white rot fungal treatment of solid waste sludge, Anaerobic ammonium oxidation process in MBBR

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Enhanced industrial activity has elevated the generation of wastewater sludge from where important nutrients can be recovered. In the European Union, the agricultural practices have contributed the most in generating sewage sludge which account for about half of the total sludge production. Heavy metals in wastewater sludge are most widely studied and they constitute a group of pollutants, which is legally restricted in most countries. Most abundant hazardous heavy metals found in sludge and soil causing pollution are: Zn, Cu, Ni, Pb, Cd, Hg and Cr. Increased concentrations of these metals are limiting nutrient recovery efficiency. Experiments were performed with molds from genus Aspergillus, oyster mushroom (*Pleurotus ostreatus*) and shiitake (*Lentinula edodes*) mushrooms in plastic containers (100-20000 mL). To allow fungal growth, moist conditions were maintained by watering the mushroom containers three times a week allowing gas exchange (escape of CO_2 and access of fresh O_2-rich air) through a membrane in the covers of containers. The amount of fungal inoculum was 2-3 % by mass. A comparison tests showed efficient metal binding and nutrients removal. Accumulation of N and P in the mushroom mass took place relatively efficiently. In Tartu and Türi WWTP composts, N contents increased from the initial level of 22 g N/ kg TSS to 40 g N/ kg TSS and 52 g N/ kg TSS within in 2 months, respectively. The highest accumulations of N and P in the mushroom mass occurred in Tartu compost in 4 months, where up to 26 g N and 14 g P/kg TSS were accumulated in the fungi. The highest N and P accumulations in the mushroom mass occurred in Tartu compost within 4 months of fungal treatment, where the mushrooms accumulated up to 37 g N and 16 g P/ kg TSS. In the raw WWTP sludge of Türi, the contents of metals decreased significantly (32-43 %) within 2 months: Cr content decreased from 22 to 15 mg/kg TSS (decrease 32%), Zn content from 692 to 406 mg/kg TSS (decrease 41%), Ni content from 22 to 15 mg/kg TSS (reduction of 32%), Cu content from 153 to 86 mg/kg TSS (reduction of 43%). In the raw sludge from Türi, the metal content decreased significantly in 2 months (up to 32-43%), but less than in the raw sludge of Tartu (54-65%). However, the results exceeded the reduction of metals in Tartu compost (up to 30%). Illumina sequencing determined groups of fungi including various molds (*Aspergillus, Penicillium, Fusarium*), white molds (*Pleurotus ostreatus* 20%) in Tartu WWTP sludge.

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Upcycling of recycled minerals from sewage sludge through black soldier fly larvae (*Hermetia Illucens*): impact on growth and mineral accumulation

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Abstract

Phosphorous (P) resources are finite. Sewage sludge recyclates (SSR) are not only of interest as plant fertilizer but also as potential mineral rich supplements in animal nutrition. However, besides P and calcium (Ca) they also contain heavy metals. According to EU legislation, the use of SSR derivatives in animal feed is not permitted, but in view of the need to improve nutrient recycling it could be an interesting mineral source in the future. Black soldier fly larvae (BSFL) convert low-grade biomass into valuable proteins and lipids, and accumulate minerals in their body. We hypothesized that BSFL modify and increase their mineral content in response to feeding on SSR containing substrates. The objective of this study was to evaluate the upcycling of minerals from SSR into agri-food nutrient cycles through BSFL. We compared growth, nutrient and mineral composition of BSFL reared either on a modified Gainesville fly diet (FD) or on FD supplemented with either 4% of biochar (FD+BCH) or singlesuperphosphate (FD+SSP) recyclate (n = 6 BSFL rearing units / group). Larval mass (LM), mineral and nutrient concentrations and yields were determined, and the bioaccumulation factor (BAF), which represents the efficiency of larvae to accumulate minerals from substrate, was calculated. The FD+SSP substrate decreased specific growth rate ($P < 0.05$) compared to FD. Larval crude fat ($P < 0.05$) was lower in FD+SSP compared to FD. The FD+SSP larvae had higher Ca and P contents and yields but the BAF for Ca was lowest. FD+BCH larvae increased Ca, iron, cadmium and lead contents compared to FD. In conclusion, BSFL incorporate Ca and P from SSR and show altered nutrient content. Except for cadmium and manganese, the heavy metal accumulation in the larvae was below the legally permitted upper concentrations for feed and food.

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Sustainable waste management model towards zero waste: a case study of Serbia

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Abstract

Circular economy has been identified as an emerging applied concept that has impact on many disciplines: sustainable development, business approach and economics. As a potential solution for proper use of resources, effective planning of material and energy consumption, and redesigning existing business processes, circular economy has been positioned as a production concept or an approach that would enable economic benefits at the same time with positive effects on the environment. Connecting circular economy with waste management system is not enough, even though waste-to-energy represents an important part of circular economy approach. Optimizing industrial energy consumption affects energy demands of an organization, while providing at the same time an economical sustainable business approach, since implementation of energy efficiency measures typically provides investment capital for other business ventures in the long run. As the circular economy represents one of the priorities in EU, the challenge is to improve the existing practices of waste management and turn them into a sustainable model that would last. The aim of this paper is to propose a model for the sustainable waste management model in industrial organizations. Production organizations have been identified as the largest generators of solid waste, wastewater, energy etc. This paper proposes the Plan-Do-Check-Act model which is the basis of the ISO 9001 as a starting point. The proposed model has been verified in industrial organizations in Serbia. The scientific benefit of the proposed model is the creation of a functionally applicable model of circular economy, applied in practice.

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Nature-based units as building blocks for resource recovery systems in cities

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Abstract

Cities are producers of high quantities of secondary liquid and solid streams that are still poorly utilized within urban systems. In order to tackle this issue, there has been an ever-growing push for more efficient resource management and waste prevention in urban areas, following the concept of a circular economy. This review paper provides a characterization of urban solid and liquid resource flows (including water, nutrients, metals, potential energy, and organics), which pass through selected nature-based solutions (NBS) and supporting units (SU), expanding on that characterization through the study of existing cases. In particular, this paper presents the currently implemented NBS units for resource recovery, the applicable solid and liquid urban waste streams and the SU dedicated to increasing the quality and minimizing hazards of specific streams at the source level (e.g., concentrated fertilizers, disinfected recovered products). The recovery efficiency of systems, where NBS and SU are combined, operated at a micro- or meso-scale and applied at technology readiness levels higher than 5, is reviewed. The importance of collection and transport infrastructure, treatment and recovery technology, and (urban) agricultural or urban green reuse on the quantity and quality of input and output materials are discussed, also regarding the current main circularity and application challenges.

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Production of biohydrogen from vine shoots

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Abstract

Fermentative hydrogen (biohydrogen) production has been widely regarded as a promising strategy for generating clean energy. An advantage of this process is that a wide variety of organic waste may be used as a substrate, which could provide an additional advantage of recycling byproduct. Vine shoots are the main byproduct generated during the vine pruning agronomic practice, with up to 2 tons of production per hectare annually. One of the environmentally friendly alternatives for the reuse of this residue is anaerobic digestion. In this way, this work presents the first report on the H_2 production of from vine shoots.

In this work, vine shoots used as substrate were pretreated by steam explosion (190 °C, 5 min, 1.63% H_2SO_4). The pretreated solid was washed three times for acid removal and taken to cellulase hydrolysis (50 °C for 72 h). The fermentative assays were conducted in the same flasks of the enzymatic hydrolysis with slurry, with added macronutrients. The inoculum (*Clostridium butyricum*) was added to the reactors. The flasks were then subjected to N_2 atmosphere for 5 min, closed with a silicone cap and plastic screw and incubated at 37 °C and 130 rpm. The final production of soluble metabolites was analyzed by high performance liquid chromatography and the H_2 content was determined using a gas chromatograph.

From vine shoots, 830.67 mL H_2/L, with yield of 3550.0 mL H_2/100 g-biomass, were produced. In addition, bioactive secondary metabolites butyric acid (1726.8 mg/L) and acetic acid (1495.3 mg/L) were also produced (Fig. 1). Comparing with other lignocellulosic wastes, the H_2 production can vary from 324.0 mL H_2/100 g-biomass with office paper waste [1] to 6116.7 mL H_2/100 g-biomass with citrus peel waste [2]. Therefore, the H_2 production from vine shoots is promising, in the sense of reuse of the waste and the potential for optimizing the process to produce greater amounts of H_2.

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The olive biomass biorefinery, a local advance in the Sustainable Development Goals

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Abstract

The Sustainable Development Goals (SDGs) are a call for action by all countries (poor, rich, and middle-income) to promote prosperity while protecting the planet, which altogether provide a roadmap for humanity toward sustainable development, according to the United Nations. Many several relevant terms have emerged which are also key to sustainable development, such as circular economy, bioeconomy, sustainability, land use, bioenergy crops, food production, resources management, etc., in close relation to SDGs [1].

To attain the SDGs, different plans are designed by governments and agencies on international and national levels, a local approach is also possible considering the biorefinery concept. Because biorefineries are usually based on the local availability of biomass, the deployment of the biorefinery can also be seen as an opportunity for contributing to the achievement of SDGs. The relationship among biorefineries, bioeconomy, and the SDGs has been evidenced through a comprehensive analysis of the technical requirements, challenges, and perspectives of biomass upgrading processes [2].

In this work, biorefineries based on olive-derived biomass are taken as a case study to analyze how their operation, even on a local and small scale, can help move towards the SDGs. For this, the main processes of conversion of the different biomasses associated with the olive tree cultivation and olive oil production process are reviewed, and the most relevant actions related to SDGs are described. Although both synergies and trade-offs can be mapped across all the SDGs, the olive biorefineries can significantly contribute to SDG#1 (No poverty), SDG#5 (Gender equality), SDG#7 (Affordable and clean energy), SDG#8 (Good jobs and economic growth), SDG#9 (Innovation and Infrastructure), SDG#11 (Sustainable cities and communities) and SDG#13 (Climate action).

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Circular economy - a concept for ensuring sustainable production and consumption of food

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Abstract

Increased production and consumption of agri-food products generate increased use of natural resources and the generation of large amounts of waste. It is characteristic of the model of a linear economy that is dominant in the world and that economy is considered to be harmful to the environment. The circular economy creates benefits and sustainability to meet economic, environmental and social challenges, it is an economic system aimed at eliminating waste and continuous use of resources.

Waste in the agri-food industry occurs in the production process, continues through the supply chain, until the consumption of the agri-food products. It shows that waste from the agro-food industry has the potential to produce very valuable semi-products and products for further application in the food industry, biotechnology and pharmaceutical industry.

The purpose of the research in this paper is to perceive the possibilities of creating a circular cycle in which food waste will be completely eliminated, to encourage the rational use and increased efficiency of resources, as well as to change the awareness and habits of youth in order to ensure a high level of protection and improving the quality of the environment.

The research was carried out within the framework of the "Youth Green Agenda" project supported by the Agency for Youth and Sports, Government of the Republic of North Macedonia, regarding recycling, rational use of resources and utilization of waste in the Republic of North Macedonia. The questionnaire that we conducted within the framework of this study contains 33 questions about the concept of the circular economy and green entrepreneurship. 300 young people participated in the research, 74% of them were female and 26% were male. The results of the research show that in R. S. Macedonia does not waste a lot of food, that is, 44.3% think that 0%-10% is wasted, while only 9% think that 41%-50% of food is wasted.

In the Republic of North Macedonia, there is a surplus of safe food that can be reused, recycled and handled properly, thus creating as little food waste as possible. In doing so, the focus should be not only on the environmental, social and economic benefits of preventing food waste, but also on the possibilities

of applying green principles in the operations of business entities from this sector. Appropriate responsible investments by agri-food companies will result in a sustainable value chain, as circular economy policies and waste management.

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Monitoring quality changes in set yoghurt produced with bioprotective cultures

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Abstract

One of the natural ways of product protection is using a bioprotective culture in order to delay spoilage from yeast and mold contamination. This study examines the effect of using bioprotective cultures during the industrial production of set yogurts. Samples were stored at three different temperatures 5, 10, and 25 °C, and quality changes were monitored. pH decreased and titratable acidity increased during the storage temperatures. The yeasty taste of samples was noticed as aging progressed at storage temperatures with different time intervals. Changes in sensory characteristics, during storage, correlated best with yeast and mold counts. At samples stored at 25 °C the first sensory and microbiological changes were noticed on the 9th day after production at samples without bioprotective cultures. Samples stored at 10 °C and 5 °C were monitored up to 49 days after production and the first changes in sensory properties were noticed at 30 and 38 days, respectively at samples without bioprotective cultures. Using bioprotective cultures in set yogurt production prolongs the shelf life of the product and improves the sensory properties of the final product and reduces waste.

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Calcium silicate hydrates substituted with Cr^{3+} ions appliance for the adsorption of Cu^{2+} ions from polluted water sources

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Abstract

Heavy metal ions contamination is a worldwide conundrum caused by natural and anthropogenic sources that face many problems related to fauna and flora [1,2]. However, calcium silicate hydrates (CSH) (which are mainly synthesized for binding materials production) can be used as adsorbents and contribute to the purge of wastewater. CSH are known as materials that are nontoxic, easily prepared, and inexpensive compared to other adsorbents [3,4]. Therefore, the aim of this work was to apply two-step technology (hydrothermal synthesis and adsorption) to reach a goal: incorporate Cr^{3+} and adsorb Cu^{2+} ions from the aqueous medium.

CSH substituted with Cr^{3+} ions (CSH-Cr_5 and CSH-Cr_{15}) were synthesized during hydrothermal treatment (1 h, 200 °C, CaO/SiO_2 = 1.5, CCr^{3+} = 5 or 15 g/l) in an unstirred suspension. Part of the synthesized compounds were additionally calcinated at a temperature of 500 °C (CSH-Cr5-500 and CSH-Cr15-500) and after investigating the properties of specific surface area used for the adsorption of Cu^{2+} ions (1 h, 25 °C, CCu^{2+} = 5 g/l). During isothermal curing all (> 99,9%) Cr^{3+} ions had incorporated into the CSH structure, and after adsorption ~ 98% of Cu^{2+} were removed. The best adsorption capacity (98.27%) performed the adsorbent named CSH-Cr_{15}-500 and during the processes 394.18 mg Cr^{3+}+Cu^{2+}/gCSH were removed from the aqueous solutions. All results are supported by instrumental analysis methods (XRD, STA, AAS, SBET, SEM/EDX).

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Economic feasibility of lignocellulosic wastes in Norway for sustainable biofuel production

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Abstract

The increasing demand for renewable energy sources and the emerging necessity for waste management solutions due to environmental concerns have sparked interest in utilizing various waste materials for biofuel production. Spent coffee ground (SCG) waste, a byproduct of coffee brewing processes and widely abundant particularly in Scandinavian countries, possesses substantial organic content and shows a promising candidate for biofuel production. The conversion of SCG waste into biobutanol involves pretreatment, enzymatic hydrolysis, Acetone-Butanol-Ethanol (ABE) fermentation, and distillation for recovery. In this study, industrial-scale biobutanol production was investigated with environmentally friendly and economically viable approaches. Scope of the study, the process flow diagram was prepared using SuperPro Designer, and some critical economic notions were estimated. Results clarified that, although batch fermentation has higher sugar conversion (0.99 g/g) and ABE yield (0.37 g/g), continuous fermentation possesses great potential for commercialization thanks to a higher production rate.

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Production of lipase on oilseed cake wastes using Pseudomonas fluorescens DSS73

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Abstract

The increasing stream of waste generated by the agri-food industry is a driving force to develop and improve alternative routes for their exploitation in various processes. Lignocellulosic waste materials, which represent a dominant part of this pool, can be successfully applied in biotechnological processes as a source of nutrients. Oilseed cakes, the by-product of oil production from oilseeds, contain residual of fatty acids that can be used by microorganisms as a carbon source for the production of i.e. lipases.

Hence, the subject of the study was the selection of waste raw material, suitable for the most effective biosynthesis of lipases carried out by the Pseudomonas fluorescens DSS73 strain, and further optimization of the process conditions.

In the first stage of the research, two waste materials were used – black cumin and pumpkin oilseed cakes. Agitate cultures (50 ml) were carried out for 5 days at 200 rpm using waste materials at 5% concentration. The enzymatic activity of lipases was determined using p-nitrophenol octanoate as a substrate. For both carbon sources used, the highest values of enzymatic activity were observed on the fifth day of culture. Subsequent studies, in which the response surface methodology was used, were carried out on black cumin oilseed cake, further successfully used in the production of a lipopeptide biosurfactant, amphisin. In the optimization process, the Box-Behnken design was used do model the simultaneous effect of three independent variables, the oilseed cake concentration (2.5-7.5%), NaCl concentration (1-100 mM) and culture duration (72-168 h), on the lipase activity (response). The obtained results allowed to define the optimal conditions for lipase biosynthesis, i.e. substrate concentration (5.1%), NaCl concentration (73.2 mM) and culture duration (130 h). The resultant enzyme was separated with SDS-PAGE electrophoresis technique and subjected to liquid chromatography linked to tandem mass spectrometry (LC-MS/MS) proteomic analysis, concluded with the identification of the protein.

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Agro-industrial oil wastes as a low-cost substrate for the production of biosurfactant *by Bacillus subtilis* #309

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Abstract

Surfactin is an extracellular lipopeptide biosurfactant produced by several Bacillus species. The simplest way for economic production of biosurfactants is the use of a low-cost medium. The agro-industrial wastes, such as distillery wastes, plant oils, and oil wastes are the alternative cheap raw materials for biosurfactants production. Black cumin, milk thistle seed, pumpkin seed, and sesame cakes, the main waste by-products of Europe vegetable oil industry, were used as substrates for surfactin production. In this work, biosurfactant production by Bacillus subtilis #309 was evaluated. The best results were obtained in a culture medium consisting of 5% (w/v) of sesame and black cumin cakes, with a surfactin production of 3.12±0.21 g/L and 2.54±0.31 g/L respectively. The characterization of the biosurfactant by Fourier transform infrared spectroscopy (FT-IR) and gas chromatography–mass spectrometry (GC–MS) revealed the presence of surfactin. Furthermore, the surfactin produced in the study exhibited emulsifying activity. Surfactin was used as emulsifiers to make O/W emulsions. The nanoemulsions were prepared by ultrasonication, and their stability has been studied by dynamic light scattering (DLS). The present findings indicated the potential of sesame and black cumin oil cakes as suitable substrates for the production of surfactin by B. subtilis #309 and application potential of the lipopeptide produced as an emulsifier.
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Microbial conversion of agro-industrial oil wastes into rhamnolipid biosurfactants by *Pseudomonas aeruginosa*

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Abstract

Several microorganisms are known to produce a wide variety of surface-active substances referred as biosurfactants. Sustainability of their production processes can be achieved, partially, using cheap substrates found among agricultural and food wastes or byproducts. It is well known phenomenon that the amount and type of a raw material contribute considerably to the production cost in most biological processes. In the present study, microbial conversion of agro-industrial oil wastes into functional bio-based biosurfactant was investigated. *Pseudomonas aeruginosa* #112 efficiently produced rhamnolipids as a glycolipid biosurfactants from agro-industrial oil wastes. The best results of rhamnolipids production (8.86 g L^{-1}) were obtained in medium containing sesame cake. The obtained surfactants reach the critical micelle concentration (CMC) at 45 mg L^{-1}, in which, it is able to reduce the surface tension of water from 72 to 32.3 $mN.m^{-1}$. A complete chemical characterization of rhamnolipids produced using the sesame cake was performed by Fourier transform infrared spectroscopy (FTIR). Purified rhamnolipids showed excellent surface-active properties in terms of formation of stable emulsion. Despite the promising results, the scalability of the process should be further investigated, especially to develop a sustainable bioprocess.

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Comparison of Antioxidant Activity of Melanin Pigment Produced by Using Carrot Waste

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Abstract

Organic wastes are important substrate sources for the production of natural antioxidants by fermentation. It is also known that nano-sized antioxidants produced by fermentation have advantages in terms of versatility and pharmacokinetics. For this reason, the production of melanin nanoparticles with antioxidant properties using different sources is gaining importance. In this study, natural melanin nano-pigment was produced by Aureobasidium pullulans NBRC 100716 strain by using carrot peel extract as a fermentation medium. Fermentation experiments were performed at 30°C using a shaking incubator at a shaking speed of 100 rpm in 300 mL cotton-plugged Erlenmeyers containing 150 mL of fermentation medium. The sizes of melanin particles extracted from the fermentation medium were investigated using Zeta Sizer and Scanning Electron microscope. It was determined that the sizes of the produced melanin particles varied in the range of 10-760 nm. After characterization of melanin samples produced in fermentation experiments, antioxidant capacities were determined by Huang et al. (2011) according to the method suggested. The antioxidant activities of natural melanin and synthetic melanin produced by fermentation were compared with butylated hydroxytoluene (BHT) and ascorbic acid. The highest antioxidant activity of 95% was determined for 0.25 mg/mL ascorbic acid. As the concentration increased, the antioxidant activity of the natural melanin sample obtained in the study approached synthetic melanin and BTH, and the total antioxidant activity of the melanin sample solution at a concentration of 0.25 mg/mL was determined as 74%. This result reveals that natural melanin produced by using carrot peel extract can be used as an antioxidant agent replacing BTH, considering only its antioxidant activity.

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Is it possible to valorize discarded seeds from unconventionally produced pumpkins?

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Abstract

Pumpkin fruit has high nutritional value, and besides, the value of this plant is that total pumpkin production and processing can fit into the concept of zero waste. It is very often grown as a side crop among rows of other plants. Local genotypes of unconventionally grown pumpkins have an added value: adaptability to specific local ecosystems and tolerance to various stress factors, which enables traditional cultivation, mostly without the use of agrochemicals. In rural areas, the pumpkin is often used for animal feed and the seeds are discarded. However, pumpkin seeds are a source of high-value pumpkin oil. Valorization of discarded pumpkin seeds is significant from the aspect of nutrition, ecology and economy. The aim of the research was to analyze the potential of local pumpkin genotypes grown unconventionally in western and central Serbia for obtaining oil. Seeds from twenty-two pumpkin genotypes were tested. The crude oil content of pumpkin seeds was determined by extraction with petroleum ether from whole pumpkin seeds in a Solvent extractor, saving solvent and time compared to classic soxhlet extraction.

The average oil content of 19 tested samples was 28.25 ±7.31% of oil per dry matter of the whole seed (seed with shell), but 3 samples had extremely low oil content 2.99±0.59%. There were 5 samples with an oil content above 35%, from which it can be concluded that they have a high potential for oil production. Moreover one genotype had a significantly higher oil content than the others, 44%, which is in the same range as conventionally grown pumpkin.

The oil content shows that local genotypes of non-conventionally grown pumpkins have the potential to use discarded seeds and their valorization by obtaining oil, and thus the potential to fulfill the concept of production with zero waste.

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Valorization of carrot pomace to cellulose and fungal biomass

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Abstract

A significant organic waste originating from vegetable sources is produced during industrial juice processing. Carrot pomace (CP) is a valuable reservoir of cellulose, hemicellulose, sugar, pectin, and minerals and during cellulose purification, a considerable portion of nutrients are discarded into wastewater. To fully utilize CP a sustainable approach was applied where fungal biomass and cellulose were produced from CP. The process involves solubilizing the non-cellulosic fractions of CP through enzymatic pretreatment pectinase and hemicellulase, followed by utilizing the dissolved fraction as a substrate for cultivating the filamentous fungus *Rhizopus delemar*. The solid fraction of CP containing cellulose, was subjected to purification steps including washing, alkali treatment, and bleaching.

Biomass concentration reached 3.6 and 4 g/l after 72 hours of cultivation using hemicellulase and pectinase pretreatments, respectively. The biomass of this fungus contains valuable materials such as chitin and chitosan. The yield of extracted cellulose after bleaching was 14.5 and 13 percent of CP after hemicellulase and pectinase treatments, respectively. Carbohydrate analysis showed respective glucan content of 63.5 and 46.6% in the isolate cellulose fraction. Fourier transform infrared spectroscopy and thermogravimetric analysis indicated the presence of cellulose after bleaching process. The extracted cellulose and fungal biomass, offer promising prospects for the development of biobased material.

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Knowledge transfer to youths: Recycling waste cooking oil of fast foods into liquid soap

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Abstract

Waste cooking oil is the oil in which significant changes have occurred on its chemical structure during frying process. Although this process gives to food special properties the use of oil several times, not only compromise the food characteristics, but can demonstrate adverse health effect for the consumer. Furthermore, inadequate management of waste cooking oil can result in environmental pollution.

The goal of our work was to transfer the knowledge and train the youths for being able to produce liquid soap from waste cooking oil. This training program is done in the framework of Project named "Sa-Punë Mjedisi". The project was implemented in three cities located in North of Albania and the target groups of the project were high school students (from 16 to 18 years old).

Optimization of all procedures related to transformation of waste cooking oil in a biodegradable product (liquid soap) was carried out in the lab and were transmitted to students in the simplest way which suited to their background. Recycling of waste cooking oil to liquid soap was performed using cold process method.

This training program increased youth's awareness on waste recycling as a potential approach for sustainability and environmental management.

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Utilization of biowaste for the extraction of metals from waste products

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Abstract

In the hydrometallurgical extraction of metals from primary and secondary resources, inorganic/organic reagents are used depending on their binding and/or oxidative/reductive properties. The mineral acids (e.g., H_2SO_4, HCl, and HNO_3) are commonly used in the leaching of metals however during their production toxic pollutants which are harmful to the environment are also released. An oxidant or reductant are also commonly used in leaching and downstream stages of metals depending on the type of the starting material and presence of metals. In recent years, use of organic reagents (e.g., citric acid, acetic acid) in hydrometallurgical recovery of metals has become forward as an alternative and environmentally friendly route for metals extraction. Waste organic residues are easily accessible vast resource for organic matter. Therefore, these organic residues or organic acids derived from these residues can be used in leaching and downstream processes which would contribute to circular economy and reduction of carbon footprint in hydrometallurgical processes. This study reviews the utilization of different kinds of biowaste as alternative resources in place of inorganic reagents in the hydrometallurgical extraction of metals from waste products.

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Application of the circular economy business model towards zero waste on the examples of innovative companies in Southeast Europe

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Abstract

The circular economy concept is garnering a lot of attention in several critical areas, including strategic management, operations management, and technology management. Businesses are becoming more and more aware of the need to develop sustainable business strategies that conserve resources and protect the environment. This article provides an overview of the current circular economy business models and investigates how they might be applied to achieve zero waste, with a focus on creative Southeast European businesses. Through an examination of case studies, this research highlights how businesses in Southeast Europe are embracing the circular economy principles to minimize waste generation and maximize resource efficiency. The examples discussed include companies operating in diverse sectors such as packaging, waste management, fashion, energy, and green technologies.

The circular economy business models adopted by these innovative companies in Southeast Europe encompass various groups associated with the circular economy concept. For instance, bioenergy from waste is addressed through the utilization of organic waste as a valuable feedstock for bioenergy production. Similarly, bio-based materials and biochemicals from waste are explored as alternatives to traditional plastics and as a means of adding value to waste streams. Additionally, the extraction of food and feed is looked at, demonstrating how businesses are using waste resources to extract useful components and minimize food waste. Furthermore, the recovery of water and nutrients from wastewater is emphasized as a critical component of sustainable water management, where companies help to save resources by putting circular economy strategies into effect. The paper also explains the importance of creating business models that are aligned with the principles of the circular economy. After a detailed review of adopted models and strategies of innovative companies in Southeast Europe, it can be concluded that the application of circular economy business models is of great importance for the successful functioning of innovative companies. Ultimately, this research contributes to the development of knowledge about how to employ the circular economy business model to achieve zero waste. The findings highlight the significance of adopting sustainable practices, building strong value networks and supply chain partnerships, and putting forward value propositions that are in keeping with the principle.

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Production of antioxidant peptides from agricultural organic waste carrot tissues

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Abstract

Carrot (Daucus carota L.) is an important tuber vegetable crop that has very valuable components in terms of nutrition and health. Bioactive peptides are specific protein fragments that have various benefits on body functions with potential significant health effects for several different purposes. Protein hydrolysates are defined as mixtures of polypeptides, oligopeptides and amino acids obtained from protein sources by partial or intensive hydrolysis. Biopeptides are considered to have advantages over conventional molecular drugs, thanks to having features such as broad-spectrum therapeutic effect, low toxicity level and structural diversity. In this study, antioxidant activities of peptides obtained from carrot tissues by enzymatic hydrolysis were determined. Carrot vegetables which were not considered to be put on market after harvest were used, with the aim of waste utilization. Antioxidant activities of protein hydrolysates, produced using Flavourzyme 500 L enzyme, were determined through three different in vitro antioxidant experiments, namely ABTS, FRAP and ORAC, with values that were found to vary between 3.34-42.06 µM TE g^{-1} protein, respectively. Carrot hydrolysates obtained by enzymatic hydrolysis were found to have considerable antioxidant activity, therefore concluded to be used as a potential source of bioactive peptide, as well as contributing to recycling of agricultural organic waste.

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Effect of temperature and butyrate concentration on butyrate degradation and methane production during anaerobic digestion

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Abstract

The excessive acidification due to the accumulation of volatile fatty acids (VFAs) is one of the most common obstacles to cause the reactor instability and failure in anaerobic digestion. VFAs concentration is regarded as a useful indicator to monitor the process stability, especially propionate and butyrate concentration. The propionate degradation process has been further studied. However, the effect of butyrate concentration on methane yield has not been studied. In this study, experiments were conducted to explore the effect of temperature (37℃ and 55℃) and butyrate concentration (2, 5, 10, 20g COD/L) on butyrate degradation and methane production. The results showed that with butyrate concentration increasing, the accumulative methane yield was gradually decreased from 321.3 to 214.2 N ml/g COD_{added}, from 308.1 to 205.5 N ml/ g COD_{added} at 37℃ and 55℃ respectively. In addition, the methane production rate was influenced by temperature and was lower at 55℃, which was in contrast with butyrate degradation. In the early stage, the degradation rate of butyrate was higher at 55℃. Whereas at the end of the reaction, the degradation rate of butyrate was higher at 37℃. The change of butyrate degradation rate at different temperature may be due to different metabolic pathway of butyrate. And the microbial communities at different temperature and butyrate concentration were detected. The exploration of butyrate degradation process and methane production at different temperature and butyrate concentration is very useful and beneficial to monitor the reactor stability.

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Use of marine and freshwater macroalgae collected in the Sea of Azov and Lithuania for the biogas production

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Abstract

As the climate warms and water pollution increases, macroalgae have become an actual problem as ecosystems are unable to break them down in natural ways. However, macroalgae can be used as an energy source to produce the biogas. Biogas yield and energy values depend on the concentration of glucose, proteins and fats in algae, so it is very important to evaluate these parameters. The green, brown, and red macroalgae found in the Sea of Azov were collected on the seashore, whereas the green macroalgae that grow in Lithuanian freshwaters, were collected from surface waters. Spectrophotometrical methods and lipid extraction (Folch method) were used for the determination of total protein, glucose and lipid concentration, respectively. Glucose and total proteins have been found to be the most prevalent in macroalgae, which affect the yield of biogas and energy value, whereas the lipid content in samples investigated varied between 1.6-3.6 %. Brown algae biomass was found to have the highest resource potential in terms of biogas production due to their high protein content, with concentrations of up to 22.6%. Glucose concentrations were up to 13.3%. Due to the abundant glucose and protein content and suitable C/N ratio in macroalgae, nutrient availability is improved, which is essential for cell growth and metabolism of various groups of microbial populations in anaerobic digestion (AD). The measurement of biogas production parameters using various types of collected macroalgae is under way.

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Determination of total phenolic and flavonoid content of ethanolic extracts of sunflower seed cake

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Abstract

Flavonoids and polyphenols impersonate a group of compounds with high antioxidant activity. Despite the fact that they may be found in all plant parts, phenolic composition is substantially changeable among them and among plants, quantitatively and quantitatively. They are known as nutraceuticals which have beneficial effects for human health. These beneficial properties are mostly attributed to their extraordinary antioxidant capacity, which take part in the prevention of various illnesses connected to oxidative stress such as immature aging, cardiovascular and neurodegenerative diseases and some cancers. By-products of oil processing contain phenolic compounds of various chemical structures such as tocopherols, carotenoids, flavonoids, lignans, lignins and tannins. In this study, contents of total polyphenols and flavonoids were determined in sunflower seed cakes in order to estimate potential of this by-product as a source of effective natural compounds. Total flavonoid content was determined by a colorimetric method with $AlCl_3$ while polyphenol content was estimated according to Folin-Ciocalteu assay. 80% ethanol and ultrasound assisted extraction at 30°C for 30 minutes was used to obtain extracts for analysis. The content of total polyphenols was in the range from 639.9 to 829.6 mg of chlorogenic acid equivalent/100 g d.m, while flavonoid content was in range from 322.2 to 497.4 mg of catehine equivalent/100 g d.m. The contents of polyphenolic and flavonoid compounds are not negligible, and these side products of the food industry could be used to obtain high-value extracts and enrich food and pharmaceutical products. Furthermore, sunflower seed cakes could be considered alternative sources for obtaining phenolic compounds from industrial by-products.

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Evaluation of the quality of gluten-free cookies prepared from hazelnut press cake flour

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Abstract

Hazelnuts are known for their abundant content of monounsaturated fatty acids (MUFAs), bioactive compounds such as vitamin E and polyphenols, dietary fiber, and a variety of essential minerals. This study explores the utilization of hazelnut press cake flour, a by-product obtained from the cold extraction process of hazelnut oil production, as a partial substitute (at 20%, 40%, and 60%) for corn flour in gluten-free cookie recipes. Additionally, the impact of replacing shortening with hazelnut oil was investigated.

The quality assessment of the cookies involved the examination of their dimensional and textural properties, color, and sensory attributes. The findings revealed that the inclusion of hazelnut press cake flour and hazelnut oil led to a decrease in cookie diameter and volume, and an increase in cookie hardness. Moreover, hazelnut press cake flour contributed to a pleasant nutty flavor and a brownish color of the cookies. These results indicate that hazelnut press cake flour can be effectively utilized as a functional and nutritional substitute for corn flour in gluten-free cookies, even in quantities as high as 60%. By doing so, it enhances the overall functional, nutritional, and sensory qualities of these products.

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Evaluation of the possible use of selected materials for the removal of humic substances from aqueous solution

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Abstract

The rapid growth of the global population and the accompanying increasing urbanization and industrialization observed continuously over the past decades, entails the production of significant amounts of wastewater. In recent years by-products generated due to the wastewater treatment process started to be perceived as a sustainable source of energy, nutrients, and other valuable compounds. Among the value-added compounds present in by-products of the wastewater treatment process, humic substances (HSs) are recognized to be extremely important due to their multidirectional usage. Due to the severe problems, which HSs cause in the wastewater treatment process, such compounds should be removed from the wastewater treatment plant systems, otherwise, they may severely impair their performance and aggravate water pollution. In recent years, special attention is paid to the possibility of using adsorption technology to remove HSs and reuse these compounds together with adsorbing material for various purposes. Since a key aspect for obtaining a safe humic product using an adsorption approach is the selection of appropriate absorbent, the presented research has focused on the evaluation of the possible use of various organic materials (also waste) and inorganic materials (including minerals and waste) as adsorbents of HSs. The obtained results indicated that among all surveyed materials OP, AAC, KN, and AECC were considered as the most efficient adsorbents of HSs, with the removal efficiency (RE) of such substances above 60%. Nonetheless, CH, MP, and VA were also characterized by the promising RE of HS ranging from 50 to 60%. The moderate RE of HSs (30 to 50%) has been in turn designated for RMC, PC, SC, and MC. It was found that the adsorption capacity (qe) of HSs on the most effective adsorbents increased linearly with the increase in the concentration of such compounds. However, the linear increase of qe was observed in the whole range of tested HS concentration (20 to 170 mg L^{-1}) only for OP, AAC, RMC, and AECC. The presented research revealed that certain waste materials possessed promising adsorption capacities of HSs. Therefore, their application as adsorbents of HSs may be economically viable, since they are easily accessible and cheap materials.

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Solid-state fermentation of specific biological residues using various fungi species to produce phenolic compounds

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Abstract

Food and wood residues are an excellent source of raw materials for environmentally friendly biotechnological processes. To this end, in this study we sought to harness the potential of bioresidues and extract increased amounts of released polyphenols from various fungal species in a solid-state fermentation process. Polyphenols are natural compounds that have great potential applications in the food, pharmaceutical and cosmetic industries, mainly due to their antioxidant capacity. We selected four fungal species, *Aspergillus niger, Rhizopus arrhizus, Pleurotus ostreatus and Aspergillus flavus*, as working organisms and used six different substrates to perform the fermentation on solid medium: used mint, green and fruit tea bags, heartwood, and bark of silver fir (Abies alba). The solid-state fermentation process was carried out successfully and lasted for 10 and 15 days. To obtain the phenolic compounds at the end of the SSF process, extraction was carried out using three techniques: Magnetic stirrer, ultrasonic sonication and accelerated solvent extraction (ASE). The samples, which in our case were extracts of polyphenolic compounds, were analysed gravimetrically and spectrophotometrically, and the profile of the compounds present was studied by high-performance liquid chromatography (HPLC). The results obtained showed that the solid-state fermentation process was successfully carried out and that higher amounts of polyphenols could be extracted from the bioresidues using suitable organisms. In order to make the overall process of phenolic compound extraction more efficient and economically beneficial, we also investigated which extraction method is the most efficient. This showed that all three techniques are comparable and effective.

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Carotenoids profile and tocols content of flowers, leaves and stems of the Wild Edible Plant, *Oxalis pes-caprae L.*

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Abstract

Wild Edible Plants (WEPs) are plants that grow without human action, using only natural resources. In earlier times, in Europe, the use of WEPs in the diet was widespread due to the lifestyle of that time; but currently these types of plants are undervalued and they are usually considered as weeds. However, WEPs could be natural sources of bioactive compounds which may be used as new ingredients to develop novel-end-products. Therefore, the objective of this study is to know more in depth the bioactive composition of *Oxalis pes-caprae L.*, a WEP belonging to the Oxalidaceae family, evaluating the carotenoid profile and tocols content by HPLC of different parts of the plant. The plant material used were flowers, leaves and stems collected in Orihuela, Alicante (Spain) during October 2022. The results showed on the leaves a greater concentration of carotenoids (12.5 mg/100 g fw), being flowers the part with the lowest concentration (1.47 mg/100 g fw). The main compounds in the carotenoid profile of *Oxalis pes-caprae* leaves were: Lutein, β-carotene and β-Cryptoxanthin showing concentrations around 4.76, 4.50 and 1.35 mg/100 g fw, respectively. The results in stems were similar than leaves; however, in flowers, the carotenoid zeaxanthin (0.17 mg/100 g) was presented in higher concentration respect to lutein (0.10 mg/100 g). Regarding the tocol composition, the highest concentration was found in leaves (7.20 mg/100 g); being α-tocopherol the major one found (6.81 mg/100 g fw). In conclusion, these results provide new information regarding the valuable content of flowers, leaves and steams of the WEP *Oxalis pes-caprae L.*, highlighting the importance of studying more in depth this type of plants, since they could be potential novel and sustainable sources of bioactive compounds for their application as ingredients in food, or in cosmetic and pharmaceutical industries, among others.

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Efficient inactivation of microorganisms for water reuse through cold plasma technology

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Abstract

The use of marginal quality waters, including treated sewage effluent (TSE), commonly referred to as reclaimed water, is a promising sustainable source of water for agriculture. As the world's population continues to grow at an unprecedented rate, demand for food is increasing, so alternative water resources are needed to offset water scarcity. Sustainable reclamation and use of reclaimed water plays a critical role in meeting the growing demand for sanitation and water supply. At the same time, the protection of human health and the conservation of ecosystems require the implementation of appropriate treatment measures. The application of treated wastewater in agriculture has shown considerable potential to improve soil fertility. Treated wastewater contains organic matter, important elements such as nitrogen (N), phosphorus (P) and potassium (K), which are important for plant growth. However, improper wastewater treatment can lead to an accumulation of pollutants and pathogens that pose a threat to the environment and public health. Therefore, controlled and appropriate reuse of wastewater in agriculture is essential to ensure the quality of crops and other irrigation applications. Cold plasma technology is a promising option for water treatment, as it is able to degrade pollutants and inactivate microorganisms without leaving behind residues of agricultural chemicals. Plasma, considered the fourth state of matter along with solids, liquids and gases, is an ionised gas that contains free radicals, charged particles (ions and electrons), photons and other radioactive components. The presence of charged particles gives the plasma electrical conductivity, while the overall neutrality is maintained by the mutual interaction.

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Application of biochar obtained from waste materials for the absorption of humic acids from the reject waters

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Abstract

The intensification of industry and agriculture resulting from the necessity to meet the demands of modern society puts a lot of pressure on soil resources. This contributes to the loss of the soil organic matter (SOM). Nowadays, the recovery of biochars (BCs) from various organic waste and their introduction into the soil is considered to be an efficient and economical approach for the issues relating to the progressing soil impoverishment, imbalance in the carbon cycle system, and sequestration of this element in soil. Indeed, BCs are known to have a positive effect on improving soil quality (including increasing soil pH, sorption and cation exchange capacity). Although the influence of BCs on the sorption of various contaminants in soil is widely examined, there is limited information regarding their capacities to sorb humic substances (HSs), which constitute basic components of SOM. Therefore, the presented research has focused on the evaluation of the capacity of selected BCs obtained from the pyrolysis of biomass originating from, i.a. organic waste (e.g. biowaste, green waste, and waste originating from the wastewater treatment process (WWTP)), which was carried out under various conditions, to sorb HSs. Since byproducts (BPs) generated at various stages of WWTP have been recently recognized as an attractive source of HSs, the main attention herein has been put on the ability of BCs to retain on their surface humic acids (HAs) and fulvic acids (FAs) extracted from the sewage sludge and abundant in the raw reject water (RWR) obtained from its treatment. The adsorption efficiency of such humic fractions exhibited by BCs was compared with the effectivity of the adsorption process for standard HAs and FAs of known structures. The results revealed that among tested BCs, these recovered from sunflowers, digestate and oaks were the most efficient absorbents for the recovery of HSs originating from RWR. The conducted work have given promising results and provide opportunities for further research. Since HSs have to be removed from RWR due to their negative effect on the performance of WWTP when being returned with RWR to the main wastewater stream, the applicability of sunflowers, digestate and oaks

BCs for the removal and simultaneous recovery of HSs makes them extremely promising materials for the protection of water and sewage management and improvement of agriculture.

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Influence of temperature on the efficacy of traditional activated sludge wastewater treatment to remove bacteria and antibiotic-resistance genes

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Abstract

Antibiotic resistance is one of the major threats to global health leading to increases in healthcare expenditures and in mortality. Simultaneously, more than half of the world's population will be affected by water shortages, making wastewater reuse one of the most promising ways to deal with water crisis. However, it has been observed that treated wastewater, even if compliant with current reuse legislation, may still contain biological contaminants such as antibiotic resistant bacteria and related genes (ARB&ARGs), which can cause resistance accumulation and proliferation, increasing health risks.

Conventional activated sludge (CAS) is the most employed technology for the secondary treatment of urban wastewaters. Although CAS process successfully reduces the abundance of total bacteria, ARB&ARGs remain in effluents. World regions with the highest temperatures are also those most threatened by water scarcity. This was a major motivation to assess if environmental temperature may affect the microbiological quality of CAS treated wastewater. Temperature, hydraulic retention time, and sludge retention time are interdependent variables that may affect CAS operation and the fitness of bacteria. Therefore, understanding how these operating parameters influence bacteria and ARB&ARGs turnover during wastewater treatment is crucial.

This study aims at assessing the effect of temperature variation on the fate of bacteria, including ARB&ARGs, during CAS treatment, to infer how variations in ambient temperature, due to seasonal or regional temperature fluctuations, can influence the loads and prevalence of ARB&ARGs in treated wastewater. To achieve this, two laboratory CAS installations were operated continuously in a UWWTP at low temperatures, of 10 ± 0.9 °C (day 1-56) and 5 ± 1.3 °C (day 56-91), or ambient temperature (20.2 ± 3.9 °C, day 1-91) performing as a control system. The remaining operating parameters were set equal in both the counterparts, and values of temperature, pH, and dissolved oxygen were monitored continuously. The abundance and prevalence of ARB&ARGs as well as bacterial community composition were accessed weekly in the final treated wastewater and in the surplus sludge.
Regardless of the operating temperature, concentration values of chemical and biological oxygen demand, total phosphorus, total nitrogen, and total suspended solids in the CAS effluents agreed with the European Council directive concerning urban wastewater treatment.

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Assessing the environmental merits of added-value commodities yielded via hydrolysis of municipal biowaste in agricultural and biochemical application

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Abstract

Municipal Biowaste (MBW) is a valuable feedstock utilized as a renewable substrate for obtaining a wide variety of bio-based products (BPs). The present study was carried out within the LIFE EBP project funded under the LIFE programme of EU. BPs employed incorporate the mixture of bioorganic molecules produced via chemical hydrolysis of MBW, aiming to evaluate at pilot-scale, i) replication of the BPs production process, ii) assessment of BPs quality and cost, iii) validation of BPs performance as fertilizers, plant biostimulants and anti-pathogen agents and iv) confirm BPs compliance with EU regulation for agriculture and environmental policy. The technology will be tested in 4 EU countries.

Agricultural trials were conducted using tomato in an automate climate control greenhouse. Common agricultural practices for tomato were employed and 1-branch pruning based in vertical orientation/growth system. Pot size was at least 9 L and drip irrigation system was applied. Analyses included basic soil physicochemical analysis, plant growth, crop production, fruit quality and leaching. Treatments conducted with BPs application included addition of 150 kg/ha.

Experiments were conducted for food waste fermentation to produce biogas and digestate with low NH_3 content. The amount of BPs used in each treatment was between 0.05-0.2% (w/w) at 55 °C. Gas samples were analyzed for CH_4, CO_2, H_2, N_2, O_2 and N_2O using Gas Chromatography. Furthermore, the samples were analyzed for NO, NO_2 and NH_3.

Depending upon MBW source, inoculum and BPs content in fermentation, up to 68% reduction of ammonium was monitored in the digestate as compared to control experiments without BPs addition. The microbial community and biogas production were not significantly affected by BPs addition. The data are consistent with biological and chemical processes occurring in BPs assisted fermentation. These

comprise ammonia production by protein hydrolysis catalyzed by proteolytic bacteria and ammonia oxidation to N_2 catalyzed by BPs. Moreover, the study will include data assessing the environmental merits of BPs addition in agricultural trials.
Based on the findings obtained, the fermentation of FW coupled to BPs addition is capable of significantly reducing the ammonia content of the digestate, while methane production was not significantly affected. The replicability of BPs derived from MBW collected in various countries has been assessed in the different industrial environments existing in each.

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Use of β-cyclodextrin as a green extraction enhancer for the ultrasound-assisted extraction of bioactives compounds from Cornelian cherry pomace

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Abstract

Nowadays, the consumers' growing interest for the improvement of public health has led to enhancement of consumption of fruits and vegetables. Industries, that process fruits, generated enormous quantities of fruits wastes (pomace, peels, stones), which are not usually managed property. These wastes are good sources of bioactives, making its recovery a green approach for their utilization. Cornelian cherry, a traditional medical plant rich in bioactives compounds such as iridoids, phenolic acids and anthocyanins, is usually utilized for the production of food products such as jams, liquors, etc. Despite its high nutritive value, exploitation of its by-products as sources of bioactive compounds is still limited. Conventional extraction techniques are characterized by the use of toxic organic solvents, low yields and high cost. The last decades, the interest of the scientific community has been focused on exploration alternative green extraction systems, such as ultrasounds, and green solvents, such as aqueous solutions of cyclodextrin. The use of green extraction systems can reduce the negative environmental impact of the conventional procedures. Cyclodextrins can be used as green extraction enhancers due to the development of inclusion complexes with semi polar bioactives compounds. As far as we know, there has been limited effort to recover bioactives from Cornelian cherry pomace (CCP) with aqueous solutions of β-cyclodextrin (β-CD). The aim of the present study was the optimization of an ultrasound-assisted extraction of bioactive compounds from CCP with the use of aqueous solutions of β-cyclodextrin as extraction enhancers. The extraction parameters, i.e. solvent:solid ratio (L/S), concentration of β-CD, duration (t) and amplitude (A), were optimized in terms of responses, such as total phenolic content, total monomeric anthocyannins and antiradical activity. The addition of β-CD in the extraction solvents was found to have a possitive effect on the recovery of the bioactives of CCP compared to water. Our proposed procedure can be considered a sustainable green approach for the utilization of the waste for food, pharmaceutical and cosmeceutical applications.

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Feed enrichment of extruded cereals with food by-product

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Abstract

The aim of the study was to develop the production of extruded feed enrichment products for animal feeding with the addition of fresh food by-products (apple pomace, carrot pomace and potato peels). Grain (corn, wheat) was mixed with fresh food by-products with 8%, 10%, 12%, 14%, 16 and 18% (w/w) extruded; the latter prepared by mixing for 4 min using a laboratory mixer. A single-screw extruder (TM Bronto, Ukraine) with a screw diameter of 10 mm was used for extrusion trials. The studies were carried out in the laboratories of the departments of grain and feeds; biochemistry, microbiology and physiology of nutrition of Odesa National University of Technology, Ukraine.

The physical properties and chemical content of food industry by-products enrichment before and after extrusion was determined. The physical properties of apple pomace, carrot pomace, potato peels and the extruded enrichment were evaluated in terms of moisture content, bulk density, flowability, angle of repose and coefficient of expansion according to standard methods and techniques recommended for scientific research. To study the chemical composition of apple pomace, carrot pomace and potato peels and the finished feed enrichment, the crude protein content, crude fat, crude fiber, nitrogen-free extractives, calcium and phosphorus were determined.

The changes in the microflora content during storage of food by-products and feed enrichments were determined according to the following microbiological indicators: MAFAnM, Filamentous fungi; Micromycetes (fungi and yeast), bacteria of the paratyphoid group (Salmonella); bacteria of the Escherichia coli group (coliforms). It was determined that the fresh food by-products have a storage period up to 48 hours. According the results the feed enrichment during extrusion lost the crude protein by 6%, crude fiber by 9.5%, crude fat by 6%, which is explained by the destruction of biopolymers. It has been theoretically substantiated and experimentally confirmed that the expediency of producing extruded feed enrichment of wheat grain and potato peels (ratio 9:1) and corn and carrot pomace (ratio 82:18) (w/w), that the extruded feed enrichment can be stored for 4 months.

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Enhancement of biogas production in a combined microbial electrolysis cell and anaerobic digestion using cattle manure

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Abstract

In this study microbial electrolysis cell and anaerobic digestion reactor were combined in a single reactor (MEC+AD) to enhance the biogas production from cattle manure at different operational conditions. It is known that voltage application to a combined system enhances the biogas production and methane rate due to improvement in hydrogenotrophic methanogenesis and electro methanogenesis.

The MEC+AD system was operated in semi-continuous mode under various operational conditions. The hydraulic retention times (HRT) ranging from 6 days to 1 day were applied to the MEC+AD in descending order. Lowering the HRT increased the organic loading rate (OLR) from 5 g VS/L/d to 30 g VS/L/d at the end of the study. In the meantime, different voltages of 0.3, 0.6, and 1.0 V were applied to the MEC+ADs and a conventional control reactor were operated at the same operational conditions. The MEC+AD system achieved 25 to 60 % higher biogas production and 10 to 21% higher organic removal rates compared to the conventional control reactor. At HRT of 3 days, MEC+AD was operated successfully while the control reactor collapsed. The applied voltage made a significant effect on the biogas production and organic removal rate. Depending on the HRT and applied voltage, biogas productions of MEC+AD system increased from 1.24 L/L/d to 5.10 L/L/d during the study. In addition, voltage application to the MEC+ADs enhanced methane content in biogas as much as 75 to 81%. The biogas yields obtained from the MEC+AD systems fed with cattle manure consists of 6% VS decreased from 378 to 169 ml/g VS due to the OLR increment from 5 g VS/L/d to 30 g VS/L/d. Combined MEC+AD shortened the hydraulic retention time as low as 1 day without a sign of inhibition. Provided that the effects of the voltage magnitude are to be compared between each other, higher biogas production (16 to 21%) was observed at higher applied voltages of 0.6 and 1.0 V, especially at high OLR conditions, compared to a low applied voltage of 0.3 V. It can be concluded that MEC+AD systems could be employed efficiently under challenging conditions where conventional anaerobic digestion cannot be used, such as short HRTs, small volume reactors, fast pretreatment, and the first stage of a two-stage reactor set-up.

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Bibliometric analysis on water footprint

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Abstract

The objective of this study is to review the literature on water footprint within the framework of bibliometric analysis by projecting the conceptual, intellectual and social structure of the topic as well. A total of 3120 documents from Web of Science and 3652 documents from Scopus published on the topic were extracted and merged. The final data consisted of 4373 documents after duplicates were removed. Bibliometrix package and Biblioshiny interface in R statistical software were utilized for bibliometric analysis. The documents were published in myriad journals (1207) with various scopes, and there was around 45% annual growth of publications until 2023 year. The core group consisted of 14 out of 1207 sources with Journal of Cleaner Production being the most active in the field (365 documents) followed by Science of the Total Environment (229 documents). The highest number of publications was from the China with (1222 documents), followed by the USA (637 documents), and Italy (303 documents). The most productive countries on the topic published single country publications in general and showed very low international collaboration on the field. The Sankey plot demonstrated that besides water footprint the China, USA and Italy were also publishing on virtual water, life cycle assessment, water scarcity and sustainability as sub-topics. The most frequent author keywords mapped after water footprint were life cycle assessment, sustainability, virtual water, carbon footprint, water scarcity, climate change, water consumption and China which demonstrate the current direction of the research area. Other notable keywords were grey water footprint, agriculture, water resources, blue water, ecological footprint, green water, water management, virtual water trade, etc. Collaboration network analysis was performed to project collaboration sub-groups on the area among countries, institutions and authors which resulted in four country, nine institution and seven author collaboration sub-networks with at least two collaborative papers.

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Whey and its assessment in sustainable dairy industry

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Abstract

In the food industry, many wastes and by-products occur during the processing stages, depending on the type of raw material. Whey is defined as a greenish-yellow liquid by-product that separates from the curd after cutting the curd and remains out of the curd. Whey (PAS) is an important dairy by-product obtained at the end of cheese production in the dairy industry. While 85% of the milk used during cheese production is separated as whey, protein, fat, lactose, mineral substances, and vitamins, which are important nutritional components, pass into whey. Whey is important in terms of containing approximately 20% of milk proteins, as well as being rich in essential amino acids and proteins with high functional properties. Whey contains sulfur-containing amino acids and branched-chain amino acids at high rates. In addition, whey containing minor components such as lactoperoxidase and lactoferrin; thanks to all these compounds in its composition, it has extremely beneficial effects on human health. As a result of the studies, it has been reported that the components in whey may have preventive or reducing effects against many health problems such as high blood pressure, asthma, cancer, muscle weakness, osteoporosis, and obesity. Considering the characteristic features of whey, Biological Oxygen Demand (BOD)1 value reaches a high value of 32.000 mg O_2/l in terms of pollution value. 1 liter of whey with this BOD value also carries a value of approximately 60.000 mg/l Chemical Oxygen Demand (COD)2. With these values, the pollution made by 1 liter of whey is equal to the pollution created by approximately 40-45 people. Whey causes important environmental problems when it is released into nature as waste without being evaluated. Due to the organic matter content in its composition, whey is a by-product with a high requirement for biological oxygen and chemical oxygen. For this reason, whey consumes the oxygen in the environment where it is thrown and harms the natural life in the ecosystem. In many countries, legal regulations have been brought in this regard, and direct release of whey into the environment without undergoing any processing is prohibited.

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Antioxidant potential of two Serbian camelina genotypes

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Abstract

In recent years, there has been a renewed interest in Camelina sativa, also known as false flax, as a potential alternative crop for oilseed production. In addition to its use as an oilseed crop, camelina has also been studied for its potential application in various industries. Besides the high nutritional value, camelina seeds contain significant amounts of biologically active substances, such as polyphenols and flavonoids. In this work, total polyphenolics and flavonoids were determined in camelina seeds. Experiments included two different camelina genotypes of camelina created through the breeding program at the Institute of Field and Vegetable Crops in Novi Sad (Serbia), which were subsequently registered by the Ministry of Agriculture, Forestry, and Water Management of the Republic of Serbia. The samples were collected between 2020 and 2021 and were stored in a refrigerator at -20°C to protect them from light and moisture. Prior to analysis, the samples were ground and passed through a 60-mesh sieve. The Folin-Ciocalteu assay was used to estimate the total polyphenol content, while a colorimetric method with AlCl3 was used to determine the flavonoid content. The DPPH radical scavenging assay was employed to determine antioxidant activity, with ascorbic acid serving as a standard antioxidant compound. The extracts used for the analyses were obtained through extraction with 80% methanol at 25°C for 24 hours. The obtained results showed that the content of total polyphenols did not vary significantly between the two varieties of camelina and was around 820 mg of chlorogenic acid equivalent/100 g d.m. Flavonoid content was in the range of 591 to 641 mg of catechin equivalent/100 g d.m. The DPPH assay indicated relatively high antioxidant potential in the seeds extract of both tested varieties, with the ascorbic acid equivalent antioxidant capacity values ranging from 235.5 to 268.0 mg/100 g dry mass. Obtained results demonstrated that camelina seeds contain highly valuable compounds which can be utilized to enrich food products or act as additives in pharmaceutical products, highlighting their potential importance.

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Microbial-driven bioremediation and resource recovery of industrial selenium pollution

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Abstract

Bacteria and selenium (Se) form a complex relationship with biogeochemical implications (Staicu et al., 2022). Selenium serves both essential (e.g. selenocysteine) and energy generation (Se can be used a terminal electron acceptor in anaerobic respiration) functions for bacterial metabolism, but it also behaves as a powerful toxicant. Conversely, bacteria are involved in all valence state transformations of Se (reductive and oxidative), contributing to the (re)cycling of this element in nature. With the advent of the Industrial Revolution, the natural cycles of numerous chemical elements, including Se, have been altered (Staicu & Barton, 2021). As such, various types of industrial effluents contain high levels of Se that pose environmental problems (Staicu et al., 2017). As a solution to this problem, industrial effluents can be treated by bioremediation using bacterial metabolism to convert soluble and toxic forms of Se into solid, non-toxic Se, Se0. These redox transformations can be harnessed to clean-up industrial pollution, and additionally coupled with the recovery of biogenic Se0 and biogas (Cordoba and Staicu, 2018). In this paper we explore the coupling of the treatment of Se-rich effluents and resource recovery using an integrated system, in the framework of circular economy. This approach not only reduces the burden of Se pollution on aquatic ecosystems, but also provides a way to recover valuable resources (Se is an important raw material for many industries; biogas is a renewable source of energy), thus generating profit and offsetting the treatment costs.

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Creating value-added products with underutilized fruits peel waste: a potential way to support sustainability and circular bioeconomy

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Abstract

Food waste is a big concern in today society, which not only has economic implications but also environmental and social consequences. There are many ways to reduce food waste, which can help to mitigate the impacts of climate change, to conserve resources, and to improve food security. Indeed, to address this issue and to find sustainable solutions, it's important to work together scientists, industries and governments. On the other hand, sustainable and healthy diets may provide many benefits for consumers, also involving reduction of food waste, and being environmentally friendly, socially responsible, and economically viable. Thus, this work aims to find a practical use for peel powder, by incorporating into cereal-based products (pancakes, muffins, and cookies), as an approach that could help in reducing food waste and promote sustainability, which aligns with the principles of the circular bioeconomy. The selected fruits (pomegranate, mandarin and banana) were bought from local farmers in 2022, Albania, their peel was sun-dried and grounded to a powder (PP). The cereal-based product (pancakes, muffins, biscuits) were prepared without PP, which served as control (P, M, C), and also samples were enriched with 6, 9 and 18%. To investigate the benefits of fruits PP can provide to products, in terms of their nutritional value and shelf life enhancement and evaluated at the time of preparation, also after 1 day, 2 days, 3 days and 5 days of storage for: physico-chemical characteristics using official methods, total phenolics according to the Folin-Ciocalteu method, total flavonoids with aluminium chloride colorimetric method, and antioxidant activity by using two tests: ABTS & DPPH, and sensoria characteristics using a 9-point scale.

The results of study showed that creation of value-added products with underutilized fruits peel waste is nutritionally advantageous, as were observed increased values of the antioxidant activity to be more than 3-fold higher; improved sensory characteristics, which are likely to be more appealing to consumers, and contributed to a longer shelf life, compared to control samples. This research work involves finding new and innovative ways to support sustainability and healthy diets, as an important part of the circular bioeconomy, by reducing and valorizing fruits peel waste, with a positive impact on the agriculture and the food, health, and energy industries.

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Life cycle analysis for the production of whey powder, lactose, succinic acid, and methane from cheese whey

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Abstract

The industrial sectors have implemented combined and integrated systems, the so-called biorefineries, to manufacture not only biofuels but also a wide range of bio-based chemicals from organic by-products and waste streams. This transition is completely consistent with the EU' efforts to promote a circular economy and its goal of becoming the first climate-neutral region in the world by 2050 through the EU Action plan for the Green Deal implementation. Among the industrial sectors producing waste and wastewater potentially suitable for biorefineries, the characteristics of cheese whey (CW) from the dairy industry may support the development of a biorefinery concept for the production of valuable bioproducts. Approximately 50–60% of whey is converted into various products. The remaining 40% is used for animal or poultry feed, sprayed over cultivated areas as fertilizers, or thrown directly into streams or rivers. CW can potentially create several significant environmental pollution problems, such as eutrophication and acidification in surface water bodies, if directly discharged into the environment without any treatment. On the other hand, CW represents a tremendous opportunity for producing green energy and platform chemicals. The different biotechnological processes were investigated in detail in the literature to volarize CW into bioenergy (methane, hydrogen, ethanol, biodiesel, bioelectricity, and power) and valuable products such fatty acids and other acids, polyhydroxyalkanoates (PHAs), disaccharides and polysaccharides, aromas and flavors, whey-based beverages, whey protein isolate, soft drinks, animal feed. The Life Cycle Assessment (LCA) methodology, which considers the impact throughout the entire life cycle, is a widely accepted tool for reaching a viable solution to evaluate the environmental impacts.

LCA, supported by ISO standards, has been widely used to assess goods, services, and processes. There are limited LCA works in the literature for assessing the environmental impacts of the dairy sector, including the sustainability of the dairy value chains, recovery of bioenergy, and use of other renewable energy sources, recycling of nutrients, recovery of PHA from permeate fraction containing lactose and wastewater treatment and valorization. The LCA concept is at the heart of this study, which investigates

producing chemicals (whey protein, lactose, whey powder, succinic acid) and generating energy (electricity, heat, and biogas) from CW sequentially produced in the real scale plant. In this study, the present and future production strategies of a whey processing factory were assessed by LCA methods. Three main scenarios were evaluated. Lactose and whey powder production processes are common for all three scenarios and labeled as Process 1st in treatment scenarios. All needed data for Process 1st was obtained from the factory as real plant data. The succinic acid production process was labeled as Process 2nd in treatment scenarios. The needed data for Process 2nd was obtained from lab scale studies. The present treatment technology of the factory was assessed as Scenario 1st. In Scenario 2nd alternative treatment technology was assessed for the present production process. In Scenario 3rd, the integration of succinic acid production into the present production process and treatment of wastes were assessed. For Scenario 2 nd and Scenario 3 rd , produced biogas was evaluated in two different pathways as direct combustion and combined heat and power (CHP) unit. SimaPro 9.11 software was used for the computational implementation of the life cycle inventory data. Eleven impact categories are assessed as abiotic depletion, abiotic depletion (fossil fuels), global warming (GWP100a), ozone layer depletion (ODP), human toxicity, freshwater aquatic ecotoxicity, marine aquatic ecotoxicity, terrestrial ecotoxicity, photochemical oxidation, acidification, and eutrophication. Also, evaluating specific environmental performances of the scenarios, Cumulative Energy Demand to assess direct/indirect energy consumptions, Carbon Footprint, and Water Footprint are evaluated.

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A sustainable biorefinery approach: Investigating the potential of waste-derived volatile fatty acids as alternative carbon source in wastewater treatment

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Abstract

The widening discrepancy between the industrialized world's need for resources and non-renewable feedstock, such as fossil-fuels, has had an alarmingly large impact on global environmental problems. Meanwhile, rather than focusing just on improving effluent wastewater quality, wastewater treatment plants (WWTPs), a critical facility for urbanization, are also coping with new, growing challenges such as energy consumption and operating costs. As a result, developing innovative strategies for next-generation WWTPs that consume less energy and that are more sustainable is critical. In conventional wastewater treatment, influent wastewater goes through different treatment stages to remove the carbonaceous compounds and nutrients. In general, biological nitrogen removal is accomplished by aerobic nitrification followed by anoxic denitrification. Denitrifiers produce nitrogen gas in the subsequent anoxic stage of denitrification, which can be released into the atmosphere by reducing the nitrate produced during the nitrification step. The problem at the denitrification stage is that, unlike nitrifying bacteria, denitrifying bacteria require organic carbon sources for growth and energy acquisition. The issue here is that, because most of the organic carbon source was depleted during the initial stages, especially post denitrification processes requires external organic carbon supplies. This ex-situ organic carbon source preparation and addition places external demands on a wastewater treatment facility, making it far from self-sustaining.

In this study, an optimum replacement for fossil-based conventional carbon sources by providing the potential of bio-based and waste-derived volatile fatty acids (VFAs)-bearing anaerobic digestion (AD) effluent was investigated in the denitrification step of wastewater treatment. Tests were performed in a lab-scale denitrification setup. While methanol has demonstrated its superiority in converting nitrate to nitrite, the results of the study showed that VFAs exhibit greater efficiency in nitrite reduction. Although the addition of AD-VFAPPL alone showed a denitrification rate (0.56±0.13 mg NOx-N removed/m^2/day) slower than that of methanol (1.04±0.46 mg NOx-N removed/m^2/day), substituting up to 50% of methanol with waste-derived AD-VFAPPL (1.08±0.07 mg NOx-N removed/m^2/day) can achieve comparable performance to pure methanol, demonstrating its potential as a viable and sustainable alternative.

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Whey valorization for biobased nanofiber membrane fabrication

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Abstract

Currently, membranes are usually fabricated, used, and disposed of according to the linear economy principle. In this way, large quantities of fossil fuel-based polymers (i.e., synthetic polymers) are used to fabricate conventional polymeric membranes. Although the synthetic polymers have some good properties (e.g., strength, mechanical stability, chemical and thermal resistance, and flexibility), they can have a negative impact on the environment if they are incinerated or disposed of without further consideration. For this reason, a serious shift from a linear economy to a circular economy should be made in membrane manufacturing. To this end, alternatives to synthetic polymers, such as bio-based polymers, should be used as raw materials for membrane fabrication. Reusing and recycling membranes that have reached their end of life is crucial, rather than disposing of and incinerating them. On the other hand, the use of fabrication techniques can reduce the generation of wastewater during membrane fabrication. Electrospinning is a method of fabricating nanofiber membranes that does not generate wastewater. Nanofiber membranes are membranes with fibers with a pore size of less than 1 µm. Nanofiber membranes have many advantages, such as high surface-to-volume ratio, adjustable interconnected pore sizes, easy surface modification and material combination, easy deposition on other substrates, and a wide range of commercial applications (e.g., medical, environmental, and energy). On the other hand, electrospinning technique has many advantages, such as higher production rate, lower cost materials, use of a wide range of polymer materials, and practical and scalable mass production. Different waste streams from different industries can be considered as sources for biopolymer production. Cheese whey, is one of the valuable discharges from dairy industry to be valorized. Its main components are protein and lactose where valuable biopolymers can be produced and recovered. Whey protein is one of the end products that can be obtained from protein while Polyhydroxyalkanoates (PHA) can be produced from lactose or hydrolyzed lactose after fermentation process.

Several studies have investigated the possibility of waste utilization from different sources for the production of biopolymers to be used for fabrication of bio-based nanofiber membranes for air and water/wastewater applications. For instance, cellulose nanocrystals, poly(lactic acid) and poly(hydroxybutyrate) can be used for aerosol removal. Moreover, poly(lactic acid), polyamide-56, chitin,

chitosan, and alginate can be used to remove particulate matter from indoor air. On the other hand, various biopolymers such as poly(lactic acid), cellulose nanocrystals, and poly(hydroxybutyrate) can be used for oil-water separation. In addition, poly(hydroxybutyrate) and alginate can be used for dye removal. Moreover, zein- and lignin-based nanofiber membranes can remove heavy metals from water samples (e.g., chromium and nickel). Last but not least, chitosan-based nanofiber membranes can also be used to remove pathogens. However, it is difficult to use the biopolymers as stand-alone polymers for the fabrication of nanofiber membranes, but to combine them with synthetic polymers to improve the mechanical and thermal stability. It was concluded that the various biopolymers from different waste sources studies used for bio-based nanofiber membranes need to be reviewed in detail for further environmental applications.

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Energy efficient membrane separation technologies: the case of gravity driven membrane

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Abstract

Since the mid-20th century, pressure-driven membrane filtration (PDM) has proven to be an effective method for wastewater treatment. PDM uses pressure as the driving force to separate water and contaminants using a semi-permeable barrier. Although it is an easily scalable method with a small footprint and effective in separating contaminants from the aqueous environment, there have been drawbacks in terms of energy consumption, membrane replacement, fouling, and cleaning, making PDM an expensive treatment method, especially for treating drinking water and domestic wastewater. In the last two decades, another filtration method has been studied and presented as an energy-efficient filtration method that uses extremely low transmembrane pressure (40-100 mbar). This method is known as gravity-driven membrane filtration (GDM). This method uses gravity, which is created by the hydrostatic pressure of the water table on the membrane surface as the driving force. Another aspect used in GDM is the formation of a biofilm layer on the membrane surface, which helps to stabilize the flux and provide additional treatment through biodegradation. In the same context, the biofilm layer allows the formation of a small region between the membrane surface and the bottom of the biofilm layer where shear forces will exist generating a cross-flow like behavior. Maintaining a stable flux provides stable operation that could last for a year without physical or chemical cleaning. The applicability of GDM is still debatable, but the main application is demonstrated for wastewater treatment in small communities. Recent research has shown that GDM application could be extended to diluted wastewater, graywater, rainwater, surface water, and desalination pretreatment. This abstract is intended to introduce the concept and applicability of GDM as an energy-efficient filtration method that could provide an alternative to PDM in small communities.

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Green extraction techniques and implementation of bioactive compounds from coffee by-products: a sustainable approach

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Abstract

In the today's world, recycling and sustainability are extremely important. The food and beverage sector is one that uses a lot of natural resources and has a big influence on the environment. As a result, adopting sustainability and recycling concepts is crucial in this sector. This research highlights the importance of recycling and sustainable practices within the food and beverage sector, focusing particularly on the coffee industry.

The coffee industry has considerable waste generation, the innovative waste reduction and recycling techniques, including the extraction of valuable compounds from coffee by-products by using green extraction techniques can contribute to environmental protection and circular economy.

In this context, ultrasound-assisted, microwave-assisted extraction, and extraction using deep eutectic solvents are presented as efficient methodologies to recover useful chemicals from coffee waste. These practices not only reduce the environmental footprint of the industry but also produce sustainable and profitable goods from waste. Applications in agriculture, animal nutrition, energy generation, and cosmetics for different coffee components are also discussed, reinforcing the potential for waste transformation into resource within a circular coffee supply chain.

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Investigation of struvite precipitation in anaerobic microfiltration osmotic membrane bioreactors

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Abstract

Phosphorus and nitrogen are needed to be recovered for the protection of the polluted environment and consumed natural resources. Struvite ($MgNH_4PO_4.6H_2O$) is a way to recover phosphorus and nitrogen from wastewater in a good manner. Struvite formation requires a medium to contain the favorable ratios of magnesium (Mg^{2+}), ammonium (NH_4^+), and phosphate (PO_4^{3-}) ions. Slaughterhouse wastewaters have a high content of organic nitrogen and a medium content of phosphorus which could be biodegraded to the NH_4^+ and PO_4^{3-}, respectively, in the bioprocesses. Besides, the studies operated to investigate the struvite formation in slaughterhouse wastewater-derived stated that the utilization of additional Mg^{2+} was needed. Recently, forward osmosis (FO) and microfiltration (MF)-based anaerobic membrane bioreactors (AnMF-OMBRs) have been studied for enhanced water and nutrient recovery. The struvite could be obtained effectively with the use of an appropriate draw solution (DS) (e.g., $MgCl_2$ or $MgSO_4$) without external addition of Mg^{2+}. In these systems, the draw solutes pass from DS to the reactor (reverse salt flux, Js), and thus the draw solute concentration increases in the reactor. When $MgCl_2$ is used as DS, the reverse salt flux of Mg^{2+} to the reactor provides the required Mg^{2+} resource for the formation of struvite. This study aims to investigate the struvite precipitation in an AnMF-OMBR, and an up-flow anaerobic sludge blanket microfiltration forward osmotic membrane bioreactor (UASB MF-OMBR) operated with $MgCl_2$ as DS. 0.47 M, 1 M, and 1.5 M DS concentrations were operated separately during the entire study. The synthetic slaughterhouse wastewater with a 5000 mg L^{-1} of COD was used as the feed solution. The conductivities of the bioreactors were kept between 8-10 mS/cm. The concentrations of NH_4^+-N and PO_4^{3-}-P were measured at certain times in the bioreactors. The NH_4^+-N and PO_4^{3-}-P concentrations increased in the bioreactors owing to the NH_4^+ and PO_4^{3-} rejection of the FO membrane during the FO membrane operation. The Mg^{2+} concentration entered the bioreactors with 0.47 M, 1 M, and 1.5 M of DS were calculated by using the values of reverse salt flux and operating time of the FO membrane. The critical supersaturation ratio (Sc) was calculated by using the concentrations of Mg^{2+},

NH_4^+, and PO_4^{3-} in the bioreactors. The results demonstrated that the struvite formation in the bioreactors was observed during each DS concentration's operation when the Sc value was higher than 1.

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Agro-food valorization and utilization of draw effluents from treatment in anaerobic osmotic membrane bioreactor of brewery wastewater

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Abstract

The brewing industry, which is one of industries that consume large amounts of water with fresh water consumption of 4–11 L per 1 L beer, generates wastewater that is genotoxic and harmful to the environment and all living things. Currently, while researching methods to reduce the need for water in the production, the focus is on the recovery and reuse of brewery wastewater through eco-friendly and footprint-reduced treatments to diminish disposal costs. Hence, circular economy-based management of these wastewaters from waste disposal to a value-added utilization in light of versatile energy, agricultural and food demands, entails the use of energy and resource-efficient methods. At this point, within rather attractive green and clean technologies, anaerobic membrane bioreactors stand out the most prominent for recovery and valorization of brewery wastewater with high carbon and nitrogen contents. Even, its forward osmosis version, i.e., anaerobic osmotic membrane bioreactor (AnOMBR), is eco-efficiently operable by higher bioenergy and fertilizer capacities due to better effluent quality, CH4 bioconversion and sludge quantity. In this regard, the current research aimed to use the diluted draw solutions (DDS) from brewery industry wastewater treated in the AnOMBR process for liquid fertilization of grass cultivation. A total of 24 different fertilizer samples including 5 tap waters at a pH range of 5.5-9.5, 8 DDSs each for CaCl2 and HCOONa, and 3 commercial fertilizer containing N, P or K was explored to monitor and evaluate the grass growing at room temperature during 30 days. First, according to recommended quantity of 50 g per m^2, grass seed of 1.25 g was planted in a 24-section wooden pot each 10 L. After applying 0.56 L liquid fertilizer separately, the sections were exposed to sunlight for 8h daily. Prior to fertilization, DDSs were diluted by tap water to decrease high salinity levels. Grass growing performances were examined by the analytical hierarchy process (AHP) based on experimental data of 10 parameters comprising the root and grass height, grass color, grass coverage percentage of soil surface, dry and wet grass weights, plant and soil water holding capacities, and sprout and fringe amounts. From the AHP analysis, 11 times diluted $CaCl_2$-DSS was found as the best with 0.066 score in front of tap water of pH 5.5 with 0.061 between all fertilizer classes. It was deduced that $CaCl_2$ as more superior than not only tap waters, but commercial products due to conservative role of Ca^{2+} ions that protect grass from infections

by hardening and strengthening of cell walls and plant tissues. On the other hand, HCOONa-DSS showed the highest performance for grass coverage percentage of soil surface. Interestingly, the lowest score exposed for phosphorus fertilizer (0.020), while nitrogen fertilizer was ascertained as more suitable for grass cultivation, especially in terms of grass color and root length. It was revealed that Ca^{2+}-containing AnOMBR osmotic solution can be successfully used as a valuable by-product for grass fertilization. This research concluded that as having greener footprints at Energy-Water-Agro-food nexus, AnOMBR technology has proven to serve to the sustainable development goals not only through circularities in water resources protection and agricultural and farming economies, but also undeniable contributions to achieving the carbon neutrality target, public health, and global prosperity.

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Earthquake waste generation estimations for cities affected by February 6, 2023 earthquakes in Türkiye

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Abstract

Disasters like earthquakes can cause severe damage and impacts, resulting in a significant amount of waste. A massive earthquake hit 13 cities of eastern Türkiye, on 6 February 2023. The aim of the study was to estimate waste generation and suggest a waste management strategy in cities affected by earthquakes. Earthquake wastes were estimated based on two distinct gross areas (120 m^2 and 150 m^2) and unit area weights derived from on-site investigations (1 t/m^2) and obtained from the Great East Japan Earthquake data (1.107 t/m^2). The estimated maximum amounts of earthquake waste generated in the cities that were mainly affected by the earthquake will be approximately 54, 23, 17 and 14 million tons in Hatay, Kahramanmaraş, Malatya and Adıyaman, respectively. The amount of earthquake waste in these cities will be ~39 to 71 times higher than the annual municipal solid waste amount. The total amount of earthquake wastes from the region will be between 100-138 million tons which is 3-4 times higher than the annual municipal solid waste amount of Türkiye. The generation of such a large amount of waste in a short time brings difficulties in the management and in finding landfills. Therefore, additional help provided from the other municipalities and the government. Separation, reuse, recycling and recovery of earthquake wastes should be ensured by applying circular economy principles. Then, the remaining wastes should be sent to landfills.

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Minimum and zero liquid discharge by advanced treatment technologies for sustainable and circular management of meat industry wastewater

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Abstract

Minimum (MLD) and zero liquid discharge (ZLD) include a strategy recovering waters used in actions from 50% to 95% and over, aligned by resource recovery and lessened cost/energy without preferably discharging any waste. Both are susceptible to less operational steps and fewer complex limitations with nearly complete performance in protecting the natural environment and all livings by means of the systematic or integrated wastewater treatments. Given 19% and 69% of the world water withdrawal by industry and agriculture, how important water recovery and reduction of discharge from water-intensive food industries is intelligible for sustainability and cleaner production. Meat production industry accounts for around one-third of the agricultural water footprint with requirements almost 10-15 m^3 of water per final products and produces cytotoxic and environmentally harmful industrial wastewaters. While new techniques developed and implemented to reduce the water use in meat processing in recent years, eco-friendly management efforts are pursued to recover and reuse of wastewaters by environmentally sound treatments. Based upon multipurpose up-to-date demands in water, food and agriculture sectors, effectiveness and viabilities of advanced technologies that will pave the way for efficient uses of water and resources are extensively researched. This study explored the treatment of integrated meat facility wastewater with a membrane oxidation reactor (MOR) followed with nanofiltration (NF) and reverse osmosis (RO). Advanced oxidation processes were investigated for the catalytic Fenton (Fe^{2+}/H_2O_2) and photo-catalytic (UVA and UVC) Fenton oxidations with catalyst and oxidant amounts and intensity of light as accompanied with the submerged ultrafiltration (UF) using different membranes. Meat wastewater was reclaimed to organics levels dischargeable to the receiving environment by MOR treatments with the best conditions of 3 Fe^{2+}/5 H_2O_2 per TOC, 24W UVA and 30W UVC irradiations, and UV150 membrane. Later, to recover water suitable for usages in industrial cooling water and agricultural landscape or grass irrigations, 10 bar NF and 20 bar RO filtrations were operated by the TDS, COD, TOC and color average removals of 57.8±4.4, 81.4±1.8, 50.8±4.5 and 95.4±3.6% for NF, and 82.5±2.5, 66.2±3.5, 54.1±4.6 and 100±0% for RO, respectively, while the best obtained with the UVC-Fenton system. Experimental studies indicated that without making dilution, the reusability of NF and NF/RO effluents was directly possible as neither cooling water nor agro-food irrigations. Because of that, lastly, 50% and above water recovery and

reuse possibilities were further examined by simulating the experimental performances of MOR-NF and MOR-NF/RO systems to the real operating conditions by using a process modelling software which establishes the mass balance between all the components under continuous flow. Simulations were solved for cases where NF and RO concentrates were feedback into the MOR to further treat the first-step reclaimed MOR waters, for making catalysis/oxidant contact times increased, due to the low soluble inert COD fraction of raw wastewater. The field-scale simulations showed that the photo-Fenton-assisted MOR-NF/RO systems provided to recover waters in the first quality of a class A for irrigation purposes for both MLD and ZLD. Cooling water could be produced by all the systems, only after applying the ion exchange process to the effluents. More importantly, it was seen that macronutrients Ca^{2+} and Mg^{2+} and micronutrient Fe^{2+} in the NF concentrates can be recovered by ion exchange in all the NF/RO-included systems as being more preferable when water recovery ratio was increased, especially more sustainably for ZLD. This research revealed that the sustainable and circular management of meat wastewater can be provided with water and resource recoveries in Water-Agro-Food system, protecting natural resources and public health in an inevitable way that will be strengthen environmental integrity, economical resilience and social welfare as compliant with sustainable development goals.