WWEM-26

ABSTRACTS E-BOOK

8th International Congress on Water, Waste and Energy Management

Gran Canaria, Canary Islands, Spain

22–24 July 2026

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Welcoming Message

Dear Colleagues,

The 8th International Congress on Water, Waste and Energy Management (WWEM-26) is organized by academics and researchers belonging to different scientific areas of Universidad de Granada, Universidad de Extremadura, Universidad de Jaén, Universidad Complutense de Madrid, University of Las Palmas de Gran Canaria, Universidad de Santiago de Compostela, University of Cassino and Southern Lazio, Hunan Agricultural University, Polytechnic Institute of Bragança, and other collaborating institutions as Spanish Adsorption Society (SEAd) and the Journal Open Chemistry.

WWEM-26 will be held in Gran Canaria, Canary Islands, Spain, from 22 to 24 July 2026. The congress will include renowned plenary and keynote speakers, oral presentations, poster sessions and technical conferences related to water, waste and energy management.

This Abstracts Book gathers the contributions accepted for presentation at WWEM-26 and provides a reference volume for participants, authors and readers interested in the scientific topics covered by the congress.

On behalf of the Organizing Committee, I would like to wish all participants a productive and enjoyable congress, with valuable opportunities to share knowledge and establish new research relationships.

Looking forward to welcoming you in Gran Canaria!

Yours sincerely,

Prof. Joaquín R. Domínguez
Full Professor of Chemical Engineering
Chairman of WWEM-26
University of Extremadura - UEx
Spain, EU

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105a · Plenary Talk	Plenary, keynote and oral presentations - Wednesday, 22 July 2026

Circular Wastewater Systems: Pathways to Water, Nutrient, and Energy Recovery

V. J.P. Vilar[1,2]*

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1. Introduction – Wastewater treatment plants have traditionally focused on protecting receiving water bodies from pollution. However, increasing resource scarcity and sustainability challenges are driving a global transition toward the recovery of resources from wastewater streams. Within this context, the Nutrients–Energy–Water (N-E-W) paradigm promotes the recovery of valuable resources to support a circular and self-sufficient bio-based economy. This work presents recent developments in circular wastewater systems, with emphasis on advanced (quaternary) treatment of urban wastewater to enable its reuse for agricultural irrigation and green hydrogen production via water electrolysis. Nutrient recovery from centrate streams is also investigated through struvite crystallization to efficiently recycle phosphorus and nitrogen. In addition, innovative strategies for hydrolyzing waste-activated sludge are explored to enhance anaerobic digestion performance and increase biogas production.

2. Results and Discussion – Enhanced ozonation strategies were developed to improve the efficiency and sustainability of quaternary wastewater treatment. Oxygen consumption was significantly reduced by recovering and recycling O_2 from O_3/O_2 gas mixtures through adsorption-based separation. In parallel, an advanced gas–liquid mixing system based on the NETmix static mixer enhanced mass transfer and enabled a compact sidestream contacting configuration. The ozonation prototype was successfully demonstrated at an urban WWTP, achieving over 80% removal of all micropollutants listed in Directive (EU) 2024/3019 with specific ozone doses below 0.65 g O_3 g^{-1} DOC. WWTPs were also evaluated as future hydrogen hubs by producing high-purity recycled water for electrolysis. A pilot treatment train combining ultrafiltration, reverse osmosis, and electrodeionization consistently produced water with electrical conductivity ≤ 1 µS cm^{-1}. Performance tests in an AEM electrolyzer showed no significant differences between reclaimed and ultrapure water. For nutrient recovery, an oscillatory flow crystallizer enabled continuous struvite precipitation from anaerobic digestate, achieving phosphorus recovery efficiencies above 80% at pH 9 with residence times of less than 4 minutes. Additionally, a thermal–solar pretreatment of waste-activated sludge using a Raceway Pond Reactor enhanced anaerobic digestion [1]. Synergistic thermal and UV exposure increased COD disintegration, pathogen removal, and biogas production, with methane yields rising by 131% compared to untreated sludge.

3. Conclusions – This work demonstrates that integrated quaternary treatment, nutrient recovery, and sludge pre-treatment strategies can transform WWTPs into efficient resource recovery facilities. These results support the role of WWTPs as key enablers of circular water, nutrient, and energy systems.

Acknowledgments – This work was supported by i) project NEWater (Water4All/0002/2022) financed by Fundação para a Ciência e a Tecnologia, I.P through national funds, under the Water4All partnership; ii) project WAVES (NORTE2030-FEDER-02716600), funded through the NORTE2030 program, under the Support System for the Creation of Scientific and Technological Knowledge – Integrated R&D Projects (SACCCT – IC&DT), call NORTE2030-2024-84 and iii) H2Driven Green Agenda, nr. C644923817-00000037, investment project nr 50, financed by the Recovery and Resilience Plan (PRR) and by European Union – NextGeneration EU. This research was also supported by Fundação para a Ciência e a Tecnologia,

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113a · Keynote Talk	Plenary, keynote and oral presentations - Wednesday, 22 July 2026

Water quantity and quality from different water sources in arid regions of South Africa

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1. Introduction - Water quality is a critical indicator of environmental health, reflecting the physical, chemical, and biological characteristics of water in relation to its suitability for various uses. Increasing anthropogenic activities, including agricultural runoff, waste disposal, and urbanization, continue to threaten both surface and groundwater resources globally. This paper focuses on assessing the amount of water available and the quality of the water found in the arid regions of South Africa. Several water sampling points were identified across the arid to hyper-arid western half of the country. Different rivers, groundwater sources, and rainwater-harvesting well points were monitored and sampled. Water samples were taken at the top of the mountains before the water passed through human settlements, waste disposal sites, and sewage effluents. Samples were also collected from rain harvesting well points as well as shallow and deep boreholes across the hyper-arid to arid region. The main aim was to quantify the amount of available water from different sources and assess its quality for suitability with regard to intended use. A flow meter was used to quantify river discharge, pump tests were conducted to quantify groundwater volumes, while the amount available from rainfall harvesting was collected with tanks and litres noted. There was more water in underground reservoirs compared to harvested rainwater and river water. The harvested water was of good quality, while the river water had its quality deteriorating depending on upstream pollution potential. Groundwater was clear, but contained heavy-metal constituents [2].

Keywords - Arid Lands, Groundwater, Pollution Potential, Rainwater harvesting, River, Water Quality

2. Experimental - Perennial rivers, non-perennial rivers, groundwater sources and rainwater-harvesting well points were monitored and sampled. Water samples were taken at the top of the mountains before the water passed through human settlements, waste disposal sites, and sewage effluents. Samples were also collected from rain harvesting well points as well as shallow and deep boreholes across the arid-hyper-arid region. The main aim was to quantify the amount of available water from different sources and assess its quality for suitability with regard to intended use. To quantify the amount of available water in rivers, the river cross-sectional area was multiplied by the velocity of the moving water, while the amount available from rainfall harvesting was collected with buckets and collected litres noted. To quantify the amount of available water underground, a pump test was conducted. A multiparameter probe was used to monitor the on-spot water quality, while water samples were also taken for further analysis in an accredited laboratory.

3. Results and Discussion - Findings showed that there was more water in underground reservoirs compared to harvested rainwater and river water in arid regions [1-2]. The harvested water was of good quality, while the river-water quality varied across different points of the river, depending on upstream pollution potential [2]. The main sources of pollution remain runoff from agricultural activities, sewage works that deposit their waste into rivers, mining activities and other anthropogenic sources. Groundwater appeared clear, but when tested, in some areas it contained nitrates, manganese, and sulphate contaminants [2].

4. Conclusions - There is more water underground than in any other source, but this water was high in nitrates, manganese, and sulphates. In local rivers, water is at risk of contamination from anthropogenic sources, upstream users need to play their part and take accountability for the part they play in the pollution of water resources. Rainwater was clean with acceptable drinking water standards; however, rainfall patterns are unpredictable in the country.

5. References

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116a · Oral Presentation	Plenary, keynote and oral presentations - Wednesday, 22 July 2026

Application of $\delta^{18}O$-PO_4 analysis to recognize phosphate origin in selected waters of the Vistula and Bug interfluve (Poland)

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Phosphorus is one of the key elements causing eutrophication. Its easily available compounds, phosphates, are widely distributed in lithosphere and hydrosphere. Phosphates can originate from natural and anthropogenic sources, such as sewage or fertilizers, therefore, identifying the main sources of P and its flow pathways in the studied geoecosystem is crucial for proper management, protection, and revitalization of water resources. Phosphorus, which has only one stable isotope (^{31}P), is strongly bound to oxygen in most compounds, allowing the $\delta^{18}O$-PO_4 isotopic signature to be used to determine its origin and as an indicator of phosphorus cycling between biomass, soils, waters, and sediments.

Our research was conducted in the selected areas of the Vistula and Bug interfluve (Poland), where high concentrations of orthophosphates (average 0.5 mg/dm³) were found in groundwater and surface water, along with low concentrations of anthropogenic indicators such as nitrates, chlorides, and sulfates. The studies were conducted in the area where relatively phosphorus-rich sedimentary rocks are common (the Maastrichtian and Tertiary formations, like opokas, margles, chalk, gaizes and sands) and river runoff is largely influenced by groundwater. The main goal of our study was to determine how significant phosphorus source in surface waters may be phosphorus leached from phosphorus-rich bedrock. Research conducted using geochemical, hydrochemical, and isotopic methods.

The results of performed geochemical analyses indicate that phosphorus in the bedrocks from the study area occurs mainly in the form of hydroxyapatite, fluorapatite, francolite and in a dispersed form associated with glauconite, with a very diverse P_2O_5 content (from less than 0.1% to over 10%). In turn, in laboratory tests of orthophosphate leaching from selected rocks showed concentration of PO_4^{3-} ions reaching several mg/dm^3, which clearly indicates the high potential of these bedrocks as a natural source of phosphorus. Here, we present data of the $\delta^{18}O$ of dissolved inorganic phosphates extracted from different types of waters (spring waters, rivers, drainage waters, WWTP effluents) from the analysed region of Poland, as well as bedrocks and fertilizers, analysed in this study. The results of $\delta^{18}O$-PO_4 from our studies shows a different ranges of $\delta^{18}O$ values in dissolved inorganic phosphate extracted from various sources and indicate, that $\delta^{18}O$-PO_4, with some limitations, could be useful tool to recognize phosphate sources and P cycling in studied area.

During the presentation, the usefulness of the $\delta^{18}O$-PO_4 signature and its limitations for the study area will be briefly presented and discussed, as well as the potential of the Vistula–Bug interfluve resources in the context of sustainable management of phosphorus resources in Poland.

These studies were founded by the Polish National Science Centre (Grant No. UMO-2020/37/B/ST10/01994).

64a · Plenary Talk	Plenary, keynote and oral presentations - Wednesday, 22 July 2026

Advanced Oxidation Technologies: Evolution, Current Advances, and Future Perspectives

G. Hodaifa

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Introduction - Advanced oxidation technologies have become one of the most relevant strategies for the treatment of water and wastewater contaminated with persistent, toxic, and poorly biodegradable compounds. These processes are mainly based on the generation of highly reactive oxygen species, especially hydroxyl radicals, which are able to oxidize a wide range of organic pollutants. Since the first applications of ozonation, Fenton chemistry, photocatalysis, and related oxidation systems, advanced oxidation processes have evolved from laboratory-scale studies to more integrated and sustainable treatment solutions.

The objective of this plenary contribution is to present the historical evolution of advanced oxidation technologies, highlighting their scientific foundations, current technological advances, and future perspectives for environmental applications. Special attention will be given to Fenton and photo-Fenton processes, heterogeneous catalysis, solar-driven systems, ozonation, photocatalysis, electrochemical oxidation, persulfate-based oxidation, and hybrid treatment schemes.

Experimental - This work is based on a critical overview of the development and application of advanced oxidation technologies in water and wastewater treatment. The analysis considers the main reaction mechanisms, catalyst design strategies, operational variables, and integration with complementary processes such as biological treatment, membrane separation, adsorption, and artificial intelligence-assisted optimization. Particular emphasis is placed on the treatment of complex industrial effluents, including agro-industrial wastewater, phenolic streams, dyes, pesticides, pharmaceuticals, and emerging contaminants.

Results and Discussion - Recent advances have significantly improved the efficiency, selectivity, and applicability of advanced oxidation technologies. The use of heterogeneous catalysts, natural minerals, supported iron materials, nanostructured oxides, and reusable catalytic systems has contributed to reducing reagent consumption and improving process stability. In parallel, solar photo-Fenton and visible-light-driven photocatalytic systems have increased the sustainability of oxidation processes by reducing energy demand.

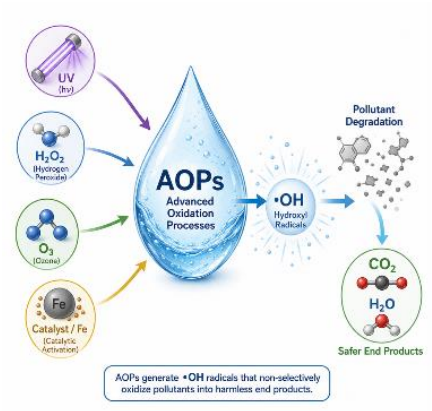

Image 1. Overview of advanced oxidation processes for water and wastewater treatment.

Current achievements also include the development of combined treatment strategies, where advanced oxidation is used as a pretreatment to increase biodegradability or as a polishing step to remove residual contaminants. In addition, digital tools, modelling approaches, and artificial intelligence are opening new opportunities for process control, optimization, and scale-up. However, important challenges remain, including catalyst deactivation, treatment cost, formation of transformation products, real wastewater complexity, and the need for pilot- and full-scale validation.

Conclusions - Advanced oxidation technologies have progressed from fundamental oxidation chemistry to versatile environmental engineering tools. Their current development is moving toward more sustainable, selective, energy-efficient, and scalable systems. Future advances should focus on the integration of

renewable energy, catalyst reuse, circular economy principles, real-effluent validation, and intelligent process optimization. These technologies will continue to play a key role in sustainable water management and in the protection of aquatic environments.

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152a · Oral Presentation	Plenary, keynote and oral presentations - Wednesday, 22 July 2026

Nickel sulfide electrocatalysts for energy-efficient urea removal and hydrogen production: influence of phase composition and sulfurization pathway

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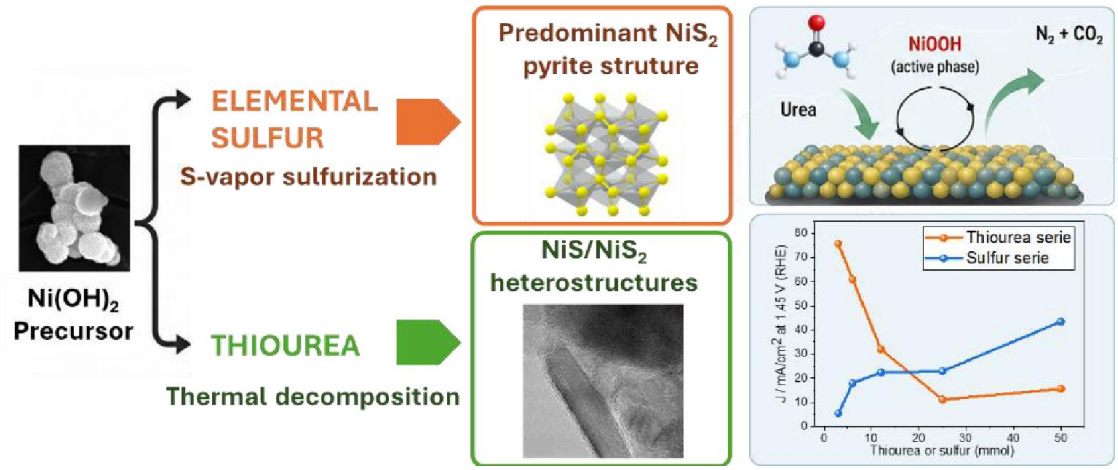
1. Introduction - In recent years, the urea oxidation reaction (UOR) has emerged as a promising alternative to the oxygen evolution reaction (OER) in alkaline media, enabling reduced energy consumption in hydrogen production while offering a viable route for the treatment of nitrogen-rich wastewater. Nickel-based materials, particularly nickel sulfides, have attracted increasing attention as electrochemically activatable precatalysts capable of transforming into NiOOH active species [1,2]. However, the relationship between synthesis pathway, phase evolution, and electrochemical performance remains poorly understood. This work aims to elucidate the influence of the sulfurization route on the structural, morphological, and electrochemical properties of NiS- and NiS2-based materials, establishing clear structure-activity relationships for the UOR electrocatalytic process.



2. Experimental - Nickel sulfides were synthesized via thermal sulfurization of Ni(OH)2 under inert atmosphere using two different sulfur sources: elemental sulfur and thiourea. The effect of precursor type and concentration on phase evolution was systematically investigated. The materials were characterized by physico-chemical techniques, and the electrochemical performance was evaluated by cyclic voltammetry in alkaline electrolyte solution (5 M KOH) in the absence and presence of urea (0.33 M).

3. Results and Discussion - The results demonstrate that the sulfurization pathway strongly influences phase composition and morphology. Sulfur vapor sulfurization predominantly yields NiS2 with relatively compact structures, whereas thiourea decomposition produces a more complex chemical environment that favors the formation of porous architectures and mixed NiS/NiS2 phases [3]. All nickel sulfide materials exhibit significantly enhanced electrochemical activity compared to the Ni(OH)2 precursor. Among them, thiourea-derived samples synthesized at low precursor concentration show the highest current densities. This behavior is attributed to the formation of NiS/NiS2 heterostructures, which promote interfacial charge transfer, increase the density of electrochemically accessible sites, and facilitate the formation of the catalytically active NiOOH phase. These findings indicate that the catalytic performance is not solely governed by sulfur content or phase purity, but by the interplay between phase composition, interfacial effects, and surface accessibility. Heterostructure materials provide a more favorable environment for urea adsorption and activation, resulting in improved reaction kinetics.

4. Conclusions - The present study demonstrates that controlled sulfurization is a key parameter in tailoring the properties of nickel sulfide electrocatalysts. The formation of NiS/NiS2 heterostructures emerges as an

effective strategy to enhance UOR performance by optimizing charge transfer, active site density, and surface accessibility. These results provide valuable insights into the design of advanced materials for energy-efficient hydrogen production and wastewater treatment applications.

Acknowledgements - The authors acknowledge financial support from Comunidad de Madrid through the SOLENER-CM project (Ref. TEC-2024/ECO-31) under the R&D Activities Programme in Technologies (2024).

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Analytical challenges for water control in electrolysis processes in H2V generation

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The large-scale deployment of green hydrogen production via water electrolysis is a cornerstone of current energy transition strategies. However, the performance, efficiency, and long-term durability of electrolysis systems strongly depend on the quality of the process water used [(1)]. Trace-level inorganic and organic impurities, even at very low concentrations, can negatively impact electrolyzer efficiency, catalyst lifetime, membrane stability, and overall operational reliability.

This work addresses the main analytical challenges in monitoring and controlling water quality for green hydrogen electrolysis, focusing on critical parameters such as ionic contaminants, dissolved metals, silica, organic carbon, and dissolved gases. These measurements demand high sensitivity and robustness, particularly in industrial environments with variable feedwater sources and dynamic operating conditions.

Different analytical strategies are discussed, including advanced chromatographic techniques, mass spectrometry, and spectroscopic methods, highlighting their advantages and limitations for routine monitoring and process control. The importance of method validation, traceability, and compliance with emerging quality standards for hydrogen production is also emphasized. Finally, this work underlines the need for integrated analytical approaches combining on-line, at-line, and laboratory-based techniques to ensure consistent water quality and support the sustainable and efficient production of green hydrogen

Conclusions

Robust and sensitive analytical control of water quality is essential to ensure the efficiency, durability, and reliability of green hydrogen electrolysis systems. Addressing trace-level impurities through validated and integrated analytical strategies is critical to support the scalable and sustainable deployment of green hydrogen technologies

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103a · Oral Presentation	Plenary, keynote and oral presentations - Wednesday, 22 July 2026

Closing the Loop: Magnesium Recovery from Desalination Brine for Struvite Production in Wastewater Treatment Plants

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1. Introduction

Stricter regulations, as outlined in Directive (EU) 2024/3019, are transforming Wastewater Treatment Plants (WWTPs) into resource recovery facilities, highlighting the need to optimise high-strength internal streams, such as sidestream digestate, which is rich in nitrogen (N) and phosphorus (P) [1]. Struvite crystallisation (MgNH4PO4·6H2O) recovers these nutrients as a slow-release fertiliser, but reliance on magnesium, a critical EU raw material, limits scalability [2]. This study aims to develop and validate a continuous oscillatory flow process for the recovery of magnesium hydroxide ($Mg(OH)_2$) by crystallisation from synthetic and real desalination brines, and to assess its use as a low-cost source for struvite crystallisation.

2. Experimental

Real desalination brine (RB) from southern Portugal and sidestream digestate (SD) from a WWTP in northern Portugal were investigated, with a synthetic desalination brine (SB) used as a pre-optimisation reference. Mg(OH)2 was recovered via selective precipitation, optimising flow rate and NaOH injection points to balance nucleation and crystal growth. The solids were washed at a controlled pH and dried at different temperatures. For struvite crystallisation, pre-filtered SD was treated with Mg(OH)2 from SB and RB as an alternative Mg source (P:Mg = 1.0:1.6), with flow rate and pH adjusted to promote crystal growth.

3. Results and Discussion

Mg(OH)2 recovery from SB was high (91.5-94.5%) and increased with flow rate without compromising solid purity (~76%), owing to an optimised demineralised water washing step that effectively removed interfering cations. Recovery from RB was slightly lower (87.6%), while maintaining comparable purity (77%), indicating the robustness of the process in complex matrices. In continuous struvite crystallisation, analytical $MgCl_2$ and both SB--$Mg(OH)_2$ and RB-$Mg(OH)_2$ achieved phosphate and magnesium recovery efficiencies above 90%; ammonium removal remained low (4-13%) due to its excess in the SD. All magnesium sources produced prismatic struvite crystals. At a hydraulic retention time of 4 min, struvite production reached ~0.7 kg m^{-3} in all trials, while the use of brine-derived $Mg(OH)_2$ reduced magnesium reagent consumption by ~40% (0.2 kg m^{-3}), with similar base demand (~0.02 kg m^{-3}).

4. Conclusions

The results demonstrate that magnesium recovered from desalination brines can serve as an efficient and economically viable input for nutrient recovery in WWTPs, while promoting the valorisation of saline waste streams and supporting circular resource management strategies.

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Acknowledgements

This work was supported by: i) LiquidMining - reference 2023.17178.ICDT (DOI: https://doi.org/10.54499/2023.17178.ICDT) funded by the European Regional Development Fund (ERDF) through COMPETE2030 (COMPETE2030-FEDER-00861300) and by national funds through FCT; iii) WAVES (NORTE2030-FEDER-02716600), funded through the NORTE2030 program, under the Support System for the Creation of Scientific and Technological Knowledge - Integrated R&D Projects (SACCCT - IC&DT), call NORTE2030-2024-84. This research was also supported by Fundação para a Ciência e a Tecnologia, I. P./MECI through national funds: LSRE-LCM, UID/50020/2025 (https://doi.org/10.54499/UID/50020/2025); and ALiCE, LA/P/0045/2020 (https://doi.org/10.54499/LA/P/0045/2020). C. Cruzeiro acknowledges her Postdoctoral Junior Leader

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Key Challenges in Modelling LFP Battery Recycling Processes

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1. Introduction - The rapid growth of lithium-ion battery (LIB) deployment is increasing the need for sustainable recycling technologies. Lithium iron phosphate ($LiFePO_4$, LFP) batteries are becoming a dominant chemistry in electric mobility and stationary energy storage, but their widespread use is expected to generate significant volumes of end-of-life units. Although LFP chemistry avoids critical metals such as nickel and cobalt, lithium (Li) recovery remains essential to reduce environmental impacts and resource dependency. At the same time, recent European regulations mandate the recycling of LIBs with minimum recovery targets, making the development of reliable recycling processes necessary even for economically challenging chemistries. However, most studies rely on laboratory-scale batch experiments and assume fixed conversion yields, which may not hold under continuous operation. This study aims to analyse an LFP hydrometallurgical recycling process at industrial-scale through modelling, focusing on the impact of equilibrium constraints and recycle streams on process performance and stability of a continuous process.

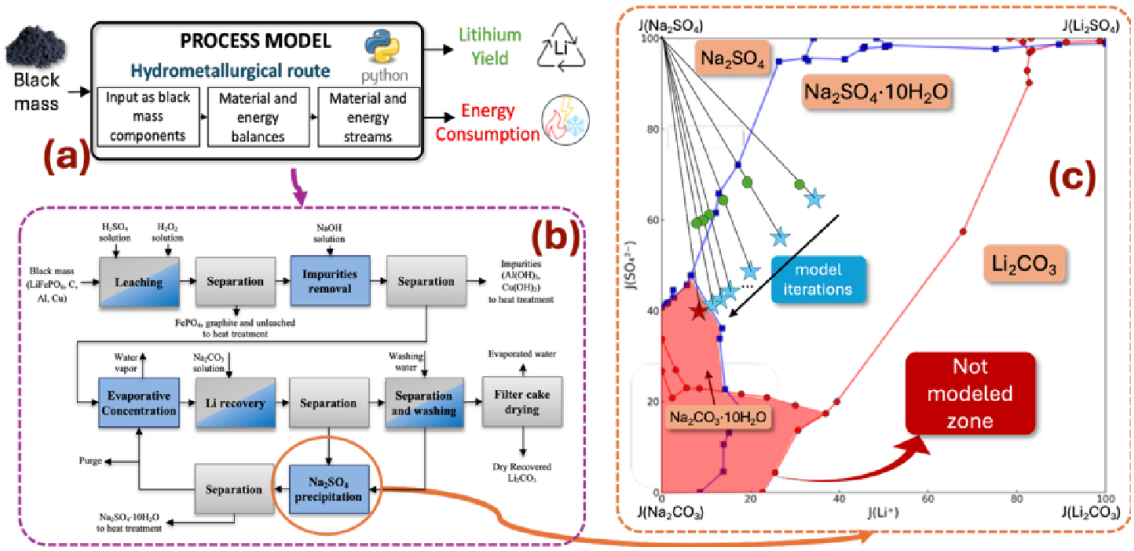

Image 1. Representation of the LFP recycling process and associated modelling framework: (a) modelling approach linking process inputs to KPI; (b) simplified process block diagram; (c) evolution of the operating point in the Li_2CO_3–Na_2SO_4–Na_2CO_3–H_2O system, showing the shift induced by recycle streams toward non-modeled regions associated with competing Na_2CO_3 precipitation.

2. Results and Discussion - A modelling framework was developed to analyse an LFP hydrometallurgical recycling process by combining mass and energy balances with equilibrium-based descriptions of inorganic precipitation (see Image 1). The process performance was evaluated in terms of Li recovery and energy demand, with particular focus on the Image 1. Representation of the LFP recycling process and associated modelling framework: (a) role of equilibrium modelling approach linking process inputs to KPI; (b) simplified process block diagram; (c) evolution of the operating point in the Li_2CO_3-Na_2SO_4-Na_2CO_3-H_2O system, showing the shift induced by recycle constraints and recycle streams toward non-modelled regions associated with competing Na_2CO_3 precipitation. streams. The results show that Li recovery cannot be described using fixed conversion efficiencies, as it strongly depends on solution composition and temperature. In this context, the use of interpolated solubility data allows the precipitation step to be modelled as an equilibrium-constrained process, providing a more realistic description compared to conventional approaches. A key finding concerns the effect of recycle streams on process behaviour. While batch equilibrium analysis identifies feasible operating conditions, the introduction of recycle loops in continuous operation leads to composition drift, which may drive the system toward competing precipitation domains. In particular, simulations performed using Na_2CO_3 concentrations typical of laboratory conditions (15 wt.%) resulted in numerical divergence, as the operating point exits the

equilibrium domain and enters regions associated with Na_2CO_3 precipitation. Stable operation was achieved only by reducing the Na_2CO_3 concentration to 5 wt.%, ensuring selective Na_2SO_4 precipitation. The reference scenario predicts a Li recovery of 78.2%, close to the European regulatory target of 80%, highlighting a narrow feasible operating window. Sensitivity analysis confirms that key parameters such as purge fraction, Li concentration and washing conditions strongly affect both recovery and process stability, revealing a tight coupling between Li recovery, energy demand, and recycle configuration.

3. Conclusions - This study demonstrates that LFP recycling processes cannot be reliably assessed using batch-based assumptions alone, as equilibrium constraints and recycle streams strongly influence process behaviour under continuous operation. The results highlight the existence of a narrow feasible operating window, where Li recovery, energy demand, and process stability are tightly coupled. The modelling framework provides a useful tool to identify stable operating conditions and evaluate process performance, supporting the scale-up of LFP recycling technologies. In addition, the analysis highlights key process units, such as the evaporative concentrator, as targets for future optimisation of energy consumption.

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Effect of aeration and filling of a full-scale pond-constructed wetland

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Introduction - Small and medium-sized communities exhibit specific wastewater production characteristics, such as high and highly variable pollutant loads. Constructed wetlands (CWs) are well suited to these communities due to their simple design and construction, efficiency, robustness, and low-cost maintenance. However, surface-flow wetlands may promote mosquito breeding, which can pose a significant public health risk. One option is to fill them with a porous medium and convert them into subsurface-flow wetlands. Gravel and sand are the conventional filling materials, but their extraction from natural environments involves mining activities with considerable environmental impacts. Therefore, sustainable alternative filling materials should be explored, such as agroforestry residues, which are abundant and locally available. Another limitation of CWs is their large land requirement, which in many cases (due to limited land availability or high land costs) restricts their applicability. In such situations, intensification techniques such as aeration or effluent recirculation can be implemented. This study investigates the effects of filling a full-scale horizontal surface-flow wetland with a forestry residue (palm branches) and applying aeration.

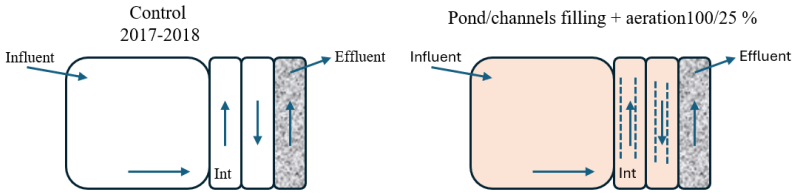

Figure 1. Experimental setup scheme.

Experimental - The experiments were conducted in the Natural Treatment System (NTS) at the Tafira Campus of the University of Las Palmas de Gran Canaria (Spain), 270 m above sea level, and average temperature of 13-24 °C. The NTS comprises a single-chamber septic tank, from which water is pumped into a facultative lagoon followed by a horizontal flow CW composed of 3 channels, the first two with surface flow and the third one with sub-surface flow[1]. Aeration (100 % and 25 % of the time) and the effect of different filling levels has been studied (Figure 1).

Results and Discussion - Conventional (BOD, COD, NH4-N, PO4-P, E. coli, turbidity, TSS) and emergent (steroid hormones) were measured. The filling material increased the removal of E. coli and total coliforms, while the combination of filling material and aeration also resulted in significant improvements in the removal of BOD_5, turbidity, and ammonium. Furthermore, the analysis of areal pollutant removal rates revealed significant increases in the removal of E. coli and total coliforms with the filling material alone, as well as of BOD_5, turbidity, E. coli, total coliforms, and ammonium when filling material and aeration were applied together. Aeration (100 % of the time) achieved almost complete steroid hormone removal.

Conclusions - There are few full-scale studies on the use of forestry residues as substrate materials and on the application of aeration in CWs. Therefore, this work may serve as a guide for the design of more robust and sustainable CWs that are better adapted to the large fluctuations in pollutant loads typically found in the wastewater generated by small communities.

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Challenges and successes of a simplified low-cost phycoremediation system to treat domestic sewage in rural areas of Africa

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1. **Introduction -** Phycoremediation stands out as an eco-friendly, low-cost technology, presenting a particularly attractive solution for wastewater treatment [1] in developing countries with temperate climates and where electricity and other services are limited [2,3]. In this study, we assess the effectiveness of the optimization of phycoremediation treatment on a wastewater treatment pond system designed to treat approximately 2.5 ML per day but receives almost double the amount of sewage effluent (4.5 ML per day). The Motetema wastewater treatment plant (WWTP), South Africa, consists of a seven-pond system that functions on a gravity-based overflow mechanism, transferring effluent from one pond to the next, and operates without mechanical aeration (Image 1). To improve the functionality of the WWTP treatment, a mass inoculation of a specific consortium of microalgae were added to the last two maturation ponds every four weeks and the effluent was analysed before and after treatment over a period of one year for nutrient reduction.

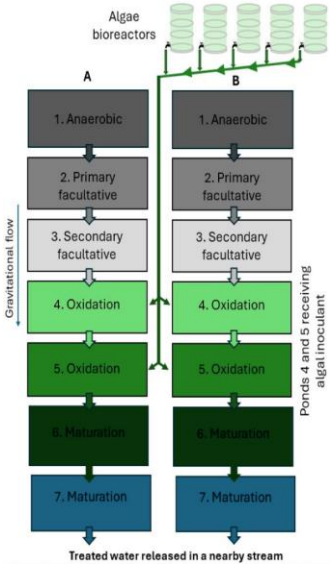

Image 1. Motetema Wastewater Treatment Plant in Sekukuniland rural South Africa.

Experimental - A consortium of microalgae were optimized under laboratory conditions and transferred to outdoor bioreactors at Motetema WWTP for testing [2]. To measure changes in the physical, chemical, and biological characteristics in the Motetema WWTP system, water samples were collected from the outlets of Ponds 6 and 7, prior to specific microalgae inoculation and one year after the commencement of continuous inoculation.

Water physicochemical parameters were assayed using standard methods [4]. In situ measurements (dissolved oxygen, DO, temperature (°C), pH, and electrical conductivity, EC) were taken monthly. Algae biomass was measured as Chlorophyll-a [3].

Results and Discussion - The physicochemical measurements confirmed a significant reduction in several parameters in the water after treatment with the microalgae consortium (Table I).

Table I. Measured reduction in the wastewater after treatment with the microalgae consortium *= seasonal variation due to climatic conditions

Physicochemical parameter	Total Nitrogen (mgL^{-1})	Total Ammonia (N) (mgL^{-1})	Total Orthophosphate (mgL^{-1})	Chlorophyll-*a** (μgL^{-1})
Before treatment	41	19	8	53
After treatment	11	0.1	1.36	180 (67)*
% Reduction	73	99	83	0

A comparative analysis of the water quality data from the final effluent of Pond 7, before and after one year of a treatment with a specific consortium of microalgae, revealed significant reductions of nutrients. For example, Orthophosphate levels decreased by 83% (from 8 mgL−1 to 1.36 mgL−1), while ammonia levels showed a 99% reduction (from 19 mgL−1 to 0.1 mgL−1), and total nitrogen was reduced by 73% (from 41 mgL−1 to 11 mgL−1). Chlorophyll-a levels steadily increased over time but temporarily decreased with seasonal changes (Table I) which affected treatment efficiency during that short period of time.

Conclusions - The consortium of a specific microalgal consortium was effective as a phycoremediation tool and reduced the measured parameters significantly, but challenges were also experienced. The decrease in productivity is likely the result of reduced light availability caused by duckweed cover and mass microalgae predation that coincided with the observed substantial increase in Daphnia and rotifer populations with the onset of summer.

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Monitoring as a tool for the protection of groundwater classified as mineral resources in Poland

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1. Introduction - In recent years, increasing attention has been paid to groundwater classified as mineral resources, including medicinal, thermal, and brine waters. This trend reflects their growing importance in the energy sector and balneotherapy, and justifies the need for more effective protection measures. Efforts to systematize this protection are reflected in European Union regulations, which define the principles for assessing both the quantitative and qualitative status of groundwater. However, these regulations do not differentiate resources based on their functional properties. Survey-based research conducted by the Polish Geological Survey (PGS, PGI-NRI) in selected European countries has shown that the protection and monitoring of groundwater classified as mineral resources are implemented in diverse and often fragmented ways [1]. In Poland, a dual legal framework applies: "ordinary" groundwater is regulated under the Water Law Act [2] and covered by environmental monitoring, whereas medicinal, thermal, and brine waters fall under the Geological and Mining Law [3], resulting in their incomplete integration within a unified monitoring system. In response to these conditions, the Polish Geological Survey has developed a concept for monitoring groundwater classified as mineral resources in Poland [1].

2. Results and Discussion - The concept of monitoring groundwater classified as mineral resources assumes the establishment of a nationwide observation and research system based on existing abstraction wells and springs that meet representativeness criteria. The authors [1] envisage conducting parallel observations at the same monitoring sites, covering both hydrodynamic parameters (including groundwater levels, spring discharge, abstraction rates, and resources) and physicochemical properties, such as ionic composition, specific constituents, and dissolved gases. The system takes into account the complex, often multi-layered structure of the deposits, focusing on reservoir aquifers while also incorporating data from the monitoring of "ordinary" groundwater in shallower aquifers. The concept assumes fixed monitoring points and periodic sampling, with data interpretation based on the analysis of parameter variability, reflecting the specific nature of these waters-typically well confined, yet sensitive to quality changes under intensive exploitation. The authors also indicate the need to delineate priority areas for resource protection, forming the basis for the organization of the monitoring system. Furthermore, they emphasize the necessity of integrating data within a dedicated database and conducting periodic technical assessments of monitoring points, which is particularly important under conditions of high mineralization and chemically aggressive waters promoting corrosion and clogging of the filter zone. This is reflected in the adoption of an individual approach to designing the structure and density of the monitoring network, with consideration of hydrogeological conditions, the level of deposit exploration, and anthropogenic pressure.

3. Conclusions - The proposed concept highlights the need for a dedicated approach to the monitoring of medicinal, thermal, and brine waters, given their specific hydrogeological characteristics and modes of use. It provides a coherent framework for assessing resource dynamics and enables the early identification of degradation processes, thereby supporting both protection measures and decision-making at administrative and economic levels. It should be emphasized, however, that although the concept provides for the designation of priority protection areas, the monitoring system should ultimately cover all abstractions of these waters. This follows from their limited renewability and the potential for cumulative impacts of exploitation within reservoir structures. An additional argument is the observed systematic increase in both the exploitable resources and abstraction volumes. In the most recent resource assessment cycle, these increases amounted to approximately 14.4% and 1.6%, respectively [4], indicating progressive resource development and growing pressure on both the quantitative and qualitative status of these waters.

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Surrogate-Based Multi-Objective Optimization of an A02A-MLE Process with Discrete Operating Constraints

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1. Introduction

Municipal wastewater treatment plants (WWTPs) generate large volumes of sewage sludge, with global production estimated at ~45 million tonnes annually (dry solids) [1]. However, this potential is limited by the high energy demand of biological nutrient removal, particularly aeration-intensive processes such as the Modified Ludzack-Ettinger (MLE) configuration [2]. Improving operational energy efficiency is therefore essential to enhance the environmental performance of WWTPs. Data-driven optimisation methods provide an effective means to explore complex, nonlinear interactions that are difficult to resolve using conventional design approaches. Kriging (Gaussian process) surrogate models, coupled with evolutionary multi-objective optimisation, enable efficient identification of trade-offs between nutrient removal efficiency, operational cost, and greenhouse gas (GHG) emissions [3, 4]. This study develops a surrogate-based multi-objective optimisation framework for an advanced AO2A-MLE process, consisting of a zero-oxygen anoxic tank (A0) followed by dual aeration tanks (2A), operating under discrete constraints.

2. Methods & Materials

The study is based on a full-scale WWTP in the UK (69,000 $m^3 \cdot d^{-1}$) operating a dual-train intermittent MLE system. Process behaviour was simulated in GPS-X using calibrated activated sludge models. 27 operational scenarios defined via a Taguchi design were simulated at four temperatures (10-40°C), generating 108 cases. Decision variables included pH, DO, carbon-to-nitrogen ratio (C/N), hydraulic retention time (HRT), influent flow rate (Qinf), and return activated sludge ratio (RAS). Operational cost and GHG emissions were derived from energy use and nitrogen pathways [2]. Surrogate models based on Kriging (Gaussian process regression) were developed to approximate the nonlinear relationships between operational decision variables and process responses. The trained Kriging models were coupled with the Non-Dominated Sorting Genetic Algorithm II (NSGA-II) to perform multi-objective optimisation and identify Pareto-optimal operating strategies under discrete constraints.

3. Results and Discussion

Kriging surrogate models achieved high predictive accuracy for all objectives ($R^2 \geq 0.91$). Integration with a discrete NSGA-II algorithm identified Pareto-optimal operating strategies across temperatures. Optimal solutions consistently favoured high carbon availability (C/N = 15) and low DO operation (0.5-0.7 $mg \cdot L^{-1}$). At lower temperatures (10-20 °C), longer HRTs and lower flow rates were required to sustain treatment performance. At higher temperatures (30-40 °C), shorter HRTs and higher hydraulic loading maintained high nutrient removal efficiencies (>99% NH_4, ~84% TN) at the expense of increased cost and GHG emissions. Influent flow rate and carbon availability emerged as the dominant control variables.

4. Conclusions

A Kriging-NSGA-II optimisation framework was developed for improving the performance of an AO2A-MLE wastewater treatment process under practical operating constraints. The results reveal clear temperature-dependent operating strategies and highlight carbon availability and hydraulic loading as key drivers of system performance. The proposed approach provides a practical decision-support tool for enhancing energy efficiency and environmental sustainability in full-scale WWTPs.

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193a · Oral Presentation	Plenary, keynote and oral presentations - Wednesday, 22 July 2026

Magnetic Wood from Forest and Wood Industry Residues: Manufacturing, Properties and Adsorption of Contaminants from Water

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Introduction - Forest residues (by-products generated from splinting, pruning and forest cleaning activities) and Wood industry residues (waste derived from the cutting and dimensioning of trunks, in sawmills and carpentry) are an environmental issue, being one of the main reasons behind wildfires [1]. Magnetic separation has been established nowadays as a smooth and gentle separating technique that reaches all sorts of materials when coupled with functionalized magnetic substances capable of absorbing all sorts of contaminants, and thus being these contaminants gently separated from the main flow [2]. The manipulation of wood and forest residues to provide them with magnetic characteristics is a current novel and breakthrough research that aims to produce valuable materials that may be further used in environmental remediation, wood applications, furniture construction, smart buildings, etc.

Experimental - In this work two main manufacturing methods were studied to obtain magnetic wood, coming from different sources of residues (saw dust, pine and acacia forest residues, hazelnut shells and cork residues): the hydrothermal method and the pressure method. The influence of key parameters, such as for example, processing temperature, reagents concentrations and quantity and type of wood was found. As an important side product, magnetic nano and microparticles were also obtained. Afterwards the magnetic characteristics of all products were determined. Adsorption properties of the prepared magnetic wood agglomerates were also studied by the application of decontamination of textile dye from water.

Results and Discussion - The two processes tested were successful in the obtention of magnetic wood substances with relevant magnetic properties (as depicted in Table I and in SEM's that will be shown), that also showed relevant adsorption properties by achieving in most of the cases adsorptions of the tested contaminants higher than 90% and adjusting mainly to a pseudo-second order

Table I. Examples of the magnetic properties of the magnetic wood and particles obtained

Initial Residue	Raw Initial Magnetic Susceptibility (m^3/kg)	Magnetic Wood Susceptibility (m^3/kg)	Magnetic Particles Susceptibility (m^3/kg)	Magnetic particles Content (%)
Hazelnut SA	$-5{,}83*10^{-9}$	$4{,}31*10^{-8}$	$7{,}46*10^{-4}$	0,01
Saw Dust AS	$1{,}42*10^{-9}$	$5{,}19*10^{-6}$	$1{,}12*10^{-3}$	0,46
Pine Forest SA	$-1{,}33*10^{-8}$	$4{,}76*10^{-7}$	$1{,}15*10^{-3}$	0,04
SawDust SA+	$1{,}42*10^{-9}$	$3{,}24*10^{-5}$	$2{,}90*10^{-4}$	11,17
Saw Dust SA+	$1{,}42*10^{-9}$	$2{,}40*10^{-5}$	$9{,}51*10^{-4}$	2,52
Saw Dust AS+	$1{,}42*10^{-9}$	$5{,}09*10^{-5}$	$1{,}15*10^{-3}$	4,43

Conclusions - Magnetic wood was successfully obtained via hydrothermal and pressure methods using forest and wood industry residues. These substances have shown to be efficient in the removal of a dye contaminant from water.

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· Poster Presentation | Poster Session WWEM-1 - Wednesday, 22 July 2026

Microwave-assisted sustainable synthesis of g-C3N4 for the efficient photocatalytic removal of the cytostatic drug 5-Fluorouracil

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1. Introduction - In recent decades, the occurrence of cytostatic drugs such as 5-fluorouracil (5-FU) in aquatic ecosystems has emerged as a significant environmental concern due to their high persistence and potential ecotoxicological impacts [1]. Since conventional water treatment methods are ineffective to remove these compounds, the development of Advanced Oxidation Processes (AOPs) has become essential. Heterogeneous photocatalysis using graphitic carbon nitride (g-C3N4) stands out for its excellent optical properties, ost-effectiveness, and environmental sustainability. In this regard, microwave-assisted synthesis represents an innovative and sustainable alternative that minimises energy consumption and allows the properties of the semiconductor to be effectively modulated using various mixtures of nitrogen-containing precursors [2]. The main objective of this study is to obtain g-C3N4 materials via a rapid and cost-effective microwave synthesis route. This work investigates the impact of using precursor mixtures on photocatalytic activity for the degradation of 5-FU under UV-A LED irradiation. Furthermore, the stability of the synthesized photocatalysts and the residual toxicity of the treated effluent are evaluated.

2. Experimental - Three series of photocatalysts were prepared by microwave-assisted synthesis using 50% (w/w) mixtures of urea/thiourea (U-TU), urea/dicyanamide (U-DCY) and thiourea/dicyanamide (TUDCY). The process was carried out in a Phoenix microwave oven at 550 °C for 3 h. The resulting materials were characterised by N_2 adsorption at -196 °C, X-ray diffraction (XRD), infrared spectroscopy (FT-IR), X-ray photoelectron spectroscopy (XPS) and UV-vis diffuse reflectance spectroscopy. Photocatalytic activity was evaluated by the degradation of 1 mg L^{-1} of 5-FU using a catalyst loading of 500 mg L^{-1} and an LED irradiation system. Studies of radical scavengers, analysis of transformation products by UPLC-MS and phytotoxicity tests were also performed.

3. Results and Discussion - The U-TU catalyst exhibited the highest performance, achieving 98.6% degradation of the contaminant in 90 minutes (kapp = 0.060 min^{-1}). This superior efficiency is based on its optimised surface area (47 m^2 g^{-1}), reduced bandgap energy (2.65 eV) and a high density of nitrogen vacancies, which acts as electron traps, inhibiting the recombination of charge carriers. Mechanism studies revealed that photogenerated holes (h^+) and singlet oxygen are the main oxidising species. Analysis of the transformation products identified six intermediates generated via hydroxylation, defluorination, and ringopening pathways. The material proved to be highly stable, maintaining 93.3% degradation after four consecutive reaction cycles. Phytotoxicity tests confirmed that the process significantly reduces the toxicity of the effluent, promoting plant growth. Table1. Physicochemical characterization of synthesized g-C3N4

Sample SBET (m2 g-1) Band-gap (eV) C/N kapp (min-1) 5-FU90 min (%) U-TU 47 2.65 0.89 0.060 98.6 U-DCY 17 2.71 0.81 0.036 94.2 TU-DCY 12 2.74 0.81 0.030 93.0

4. Conclusions - The microwave-assisted synthesis of g-C3N4 from urea and thiourea yields a highly efficient and stable photocatalyst for the remediation of cytostatic drugs. The process not only effectively removes 5-FU but also significantly reduces the toxicity of the treated effluent, as confirmed by phytotoxicity assays. This study establishes this technology as a low-cost and sustainable alternative for the treatment of persistent pharmaceutical contaminants.

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TiO_2/g-C_3N_4/GO Photocatalysts for Acetaminophen Degradation in Real Water Matrices

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Introduction - The increasing occurrence of contaminants of emerging concern in aquatic environments has raised significant concerns regarding water quality and ecosystem safety. Conventional wastewater treatment plants are often insufficient for the complete removal of these persistent compounds, promoting their continuous release into natural water bodies [1]. Acetaminophen (ACT), a widely used pharmaceutical classified as an emerging contaminant, is frequently detected in wastewater effluents and surface waters. In this context, the development of advanced oxidation processes (AOPs), particularly visible-light-driven photocatalysis, has emerged as a promising strategy for the efficient degradation of recalcitrant pollutants. The design of highly efficient photocatalysts capable of enhancing charge separation and extending visible light absorption remains crucial to improve photocatalytic performance and facilitate the implementation of sustainable water treatment technologies.

Experimental - In this work, a ternary heterojunction based on TiO2, graphene oxide (GO), and g-C3N4 (TiO2/g-C3N4/GO) was synthesised through a solvothermal approach [2] and evaluated for the photocatalytic degradation of ACT under visible light irradiation. Different GO loadings were investigated to assess their influence on photocatalytic activity. The structural, optical, and electronic properties of the prepared materials were characterised by diffuse reflectance spectroscopy (DRS), photoluminescence spectroscopy (PL), and Fourier transform infrared spectroscopy (FTIR). The photocatalytic performance of the most promising material was further evaluated in different aqueous matrices, including ultrapure water, wastewater, and river water. Scavenger and reusability experiments were also performed to investigate the photocatalytic mechanism and catalyst stability.

Results and Discussion - The results revealed that the photocatalytists performance strongly depends on GO content. Among the prepared materials, TiO2/g-C3N4/GO(0.5%) exhibited the highest photocatalytic efficiency, indicating that controlled GO incorporation promotes charge transfer and suppresses electron-hole recombination. In contrast, excessive GO loading negatively affected photocatalytic activity, which seems due to light shielding effects and blockage of active sites. The photocatalytic degradation efficiency followed the order: ultrapure water > wastewater > river water, confirming the influence of matrix complexity on photocatalytic performance.

Conclusions - The TiO2/g-C3N4/GO heterojunctions demonstrated promising visible-light-driven photocatalytic activity for the degradation of ACT in different aqueous matrices. The optimisation of GO content was crucial to enhance charge separation and improve photocatalytic performance. Despite the reduced degradation efficiency observed in real water matrices, the photocatalyst maintained significant activity under complex conditions, highlighting its potential applicability for wastewater treatment. The good stability and reusability further support the potential of TiO2/g-C3N4/GO(0.5%) as an efficient photocatalyst for the removal of pollutants from water environments.

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Life Cycle Assessment of Conventional Diesel and HDPE-Derived Pyrolytic Fuel

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1. Introduction - The intensive use of fossil fuels such as diesel poses significant environmental and sustainability challenges. In this context, plastic waste valorization through thermochemical processes, such as high-density polyethylene (HDPE) pyrolysis, has emerged as a promising alternative for fuel production [1]. This study aims to evaluate and compare the environmental impacts of conventional diesel and a pyrolytic fuel derived from HDPE waste using a Life Cycle Assessment (LCA) approach.

2. Experimental - Materials and Methods - The study was conducted following the LCA methodology using SimaPro software, in accordance with ISO 14040 and 14044 standards. A cradle-to-gate approach was adopted to assess environmental impacts from raw material extraction to fuel production. Two systems were defined: (i) conventional diesel production, modeled using processes available in the SimaPro database, including crude oil extraction, refining, and associated inputs such as water, hydrogen for hydrotreatment, catalysts, and energy consumption; and (ii) pyrolytic fuel from HDPE waste. Due to the lack of database information, a custom model was developed that includes plastic waste pre-treatment (cleaning with water) and the pyrolysis process, accounting for the associated energy requirements. Impact assessment was carried out using the ReCiPe 2016 method (endpoint and hierarchical perspectives), which aggregates results into three damage categories: human health, ecosystems, and resources. The functional unit was defined as 1 kg of fuel to ensure comparability between systems.

3. Results and Discussion - The results show relatively small differences in environmental impacts between the two fuels. In the human health category, the pyrolytic fuel exhibits a slightly higher impact, primarily due to emissions from the pyrolysis process. No significant differences were observed in the ecosystems category. However, in the resources category, the HDPE-derived fuel reduces fossil resource consumption by using plastic waste as a feedstock.

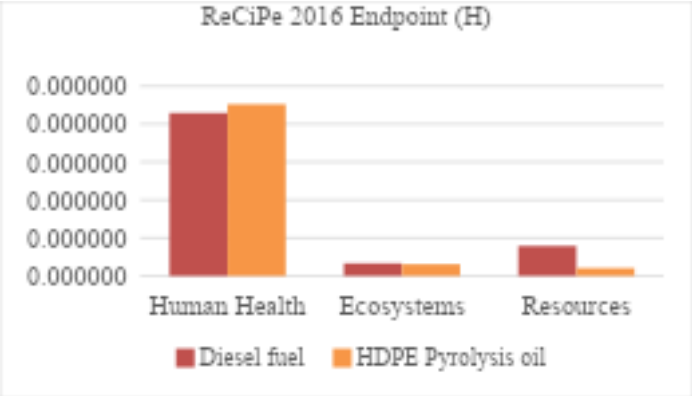

Image 1. Comparison of normalized impact results for HDPE-derived pyrolytic fuel and diesel across the categories of human health, ecosystems, and resources.

Overall, the analysis highlights that pyrolytic fuel offers environmental advantages in terms of resource depletion, supporting its potential as a circular alternative to conventional fossil fuels.

4. Conclusions - The study demonstrates that HDPE-derived pyrolytic fuel can be a viable alternative to conventional diesel from an environmental perspective, particularly in terms of waste valorization and reduced fossil resource use. By diverting plastic waste from landfills and reintroducing it as an energy source, this pathway contributes to resource conservation. However, improving the efficiency of the pyrolysis process is essential to enhance its overall environmental performance. Optimization of process stages and the integration of more sustainable energy sources are key factors to maximizing environmental benefits. Finally, the application of LCA methodologies such as ReCiPe 2016 (endpoint approach) provides a comprehensive framework to support decision-making in the development of alternative fuels.

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Experimental Evaluation of Ex-Situ Hydrogen Biomethanation in a Mesophilic Fed-Batch Reactor

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1. Introduction- Ex-situ hydrogen biomethanation technologies enable the conversion of surplus renewable electricity into grid-compatible methane (CH_4) through the reaction of hydrogen (H_2) and carbon dioxide (CO_2) mediated by hydrogenotrophic methanogens, providing a flexible and efficient energy storage solution.

2. Experimental- In this study, an ex-situ H_2 biomethanation process was carried out in a lab-scale fed-batch mesophilic reactor operated at 38°C and inoculated with digested sewage sludge under strictly anaerobic conditions. The system was operated using a cyclic strategy consisting of sequential gas feeding, reaction, and discharge phases. Hydrogen was supplied during the feeding phase via pressure-controlled injection, increasing the reactor pressure from 1100 to 1400 mbar(a). CO_2 addition was regulated based on the dissolved CO_2 concentration in the liquid phase, thereby improving gas-liquid mass transfer and promoting methane production. The experimental campaign was divided into three operational phases characterized by progressively decreasing dissolved CO_2 setpoints (from 25 to 2 mg L^{-1}) in the liquid phase. This phased design enabled systematic evaluation of microbial acclimation and process robustness under progressively intensified hydrogen feeding conditions.

3. Results and Discussion- Despite a significant accumulation of volatile fatty acids (VFAs) up to 3 g L^{-1} and a temporary decrease in pH during the second stage, continuous monitoring of the system enabled timely adjustment of operational parameters. By progressively reducing the CO_2 injection rate based on dissolved CO_2 measurements, process stability was quickly restored, demonstrating strong biological resiliency. In the subsequent stable phase (last stage), the average CH_4 concentration reached 93.5%, hydrogen utilization efficiency was 99%, and the methane evolution rate (MER) was 3.95 NL CH_4 LVR^{-1} d^{-1}. Meanwhile, VFA concentrations stabilized at 1.04 g L^{-1} and pH recovered to 7.7, indicating successful metabolic adaptation of the microbial community. Comparison with literature data (Table 1) shows that the proposed strategy provides competitive methane purity and relatively high productivity under intermittent feeding conditions.

Table 1. Comparison of Reactor Performance: This Study vs. Previous Studies VR = Volume Reactor; CSTR = Continuously Stirred Tank Reactor; BCR = Bubble Column Reactor

Type	Reactor Type	Gas Feed	Temp (°C)	VR (L)	CH_4 (%)	MER (NL CH_4 L^{-1} d^{-1})	Reference
Ex-situ	CSTR	Intermittent	38	1.4	93.3	3.95	This study
Ex-situ	CSTR	Intermittent	35	0.69	82.7	0.065	[1]
Ex-situ	BCR	Continuous	37	2	87	4.42	[2]

4. Conclusions- This study demonstrates that ex-situ hydrogen biomethanation can be effectively operated under dynamic conditions using a pressure-controlled gas feeding strategy and dissolved CO_2-based control.

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K-modified TiO2-based catalytic materials for hydrogen release from formate solutions

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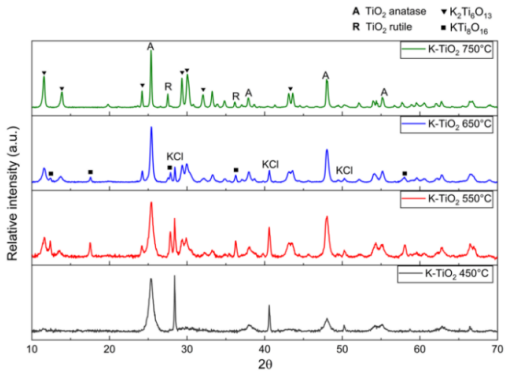
1. Introduction - Due to the increasing global energy demand, hydrogen is considered as a key energy vector for a sustainable low-carbon future. However, its storage and transportation remain a major challenge. In this context, the formate/formic acid system has emerged as a promising hydrogen carrier owing to its safety, stability and high hydrogen content. An efficient hydrogen release relies on the catalytic dehydrogenation of formic acid, where Pd-based catalysts and light-assisted systems have shown significant potential. Motivated by this catalytic transformation, K-modified TiO2 materials were explored as supports for Pd-based photocatalytic systems.

2. Experimental - K-modified TiO2 materials were synthesized via a sol-gel method using KOH as a potassium precursor. The most active sample was further loaded with Pd nanoparticles through different methods and with various metal contents. The obtained materials were characterized by physicochemical techniques. Photocatalytic formic acid decomposition was studied under UV irradiation and mild thermal conditions, while gaseous products were analysed by GC.



2. Results and Discussion - The highest photocatalytic activity was observed for the K-modified TiO2 sample calcined at 650 °C, which showed a catalytic performance comparable to commercial P25. As shown in Figure 1, K modification shifts the optimal calcination temperature by modifying phase evolution. While undoped TiO2 exhibits maximum activity at 450 °C (with significant rutile formation), K-modified samples retain the anatase phase up to higher temperatures, delaying rutile formation to 750 °C. The enhanced activity is attributed to the formation of anatase/potassium titanate heterostructures. For Pd incorporation via impregnation method, an optimal Pd loading of 2-4 wt% provided an improved dispersion, while higher loadings led to aggregation, as confirmed by TEM. Under combined UV irradiation and mild heating, a synergistic photo-thermal effect was observed, enhancing formic acid decomposition. GC analysis confirmed hydrogen as the main product, with a content of 29-35% (vol.). Slightly higher hydrogen production was achieved for Pd/K-TiO_2 (650 °C) compared to Pd/commercial P25 samples.

3. Conclusions - K-modified TiO2 shows good photocatalytic activity due to improved phase stability and heterostructure formation. Pd incorporation promotes charge separation, enabling efficient H2 production from formic acid under photo-thermal conditions. These results highlight the potential of this system for hydrogen storage and release within the formate-bicarbonate cycle.

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Co-precipitation and electrodeposition of $Ni_2Fe(CN)_6$ Prussian Blue Analogues on Ni foam for enhanced urea electrooxidation and hydrogen production

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1. Introduction - Prussian Blue (PB) and its analogues (PBA) are a class of metal-cyanide framework materials with open porous structures and multiple redox-active metal centers, making them highly promising for electrochemical applications. Ni-based PBAs such as Ni2Fe(CN)6 have shown remarkable catalytic activity toward the urea oxidation reaction (UOR) due to the synergistic interaction between Ni and Fe, which improves electron transfer and reaction kinetics [1,2]. The use of UOR as an alternative anodic reaction reduces the energy demand of water electrolysis, enabling more efficient hydrogen production. In this work, Ni2Fe(CN)6-based electrodes were prepared via co-precipitation and electrodeposition on Ni foam supports, aiming to evaluate their electrochemical performance and identify the optimal synthesis conditions for enhanced catalytic activity and stability.

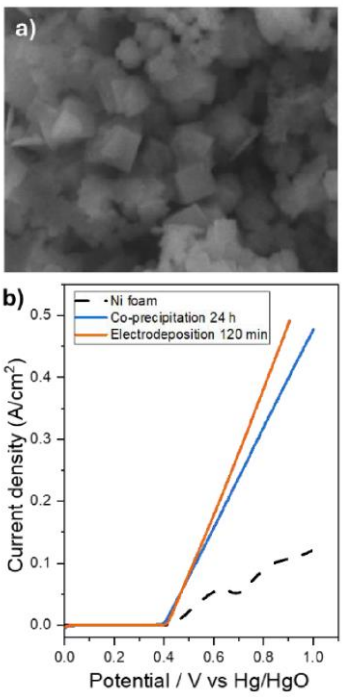

Imagen 1. a) SEM imagen of PBA cubes synthetized by electrodeposition. b) LSV of UOR of most active electrocatalysis compared to Ni foam.

2. Experimental - Ni2Fe(CN)6 PBA on Ni foam electrodes of 1 cm2 was prepared by: (i) the co-precipitation method using K3[Fe(CN)6] and NiCl2 as precursors and sodium citrate as reductor and PVP as stabilizer, allowing a controlled growth within the porous structure; and (ii) electrodeposition in a three-electrode cell using cyclic voltammetry (0-1 V, 100 mV·s-1). Electrochemical characterization was performed by linear sweep voltammetry (LSV) in 1 M KOH and 1 M KOH + 0.33 M urea. Imagen 1. a) SEM imagen of PBA cubes

3. Results and Discussion - Coprecipitation and electrodeposition differ synthesized by electrodeposition. b) LSV of UOR of most active electrocatalysis markedly in synthesis time, requiring hours-days and minutes, compared to Ni foam. respectively. In all cases, the incorporation of $Ni_2Fe(CN)_6$ with both methods significantly enhances both OER and UOR compared to bare Ni foam, with a much more pronounced improvement observed for UOR. For the samples obtained through co-precipitation, longer synthesis times improve OER activity, whereas the best UOR performance is obtained at 24 h, showing the lowest onset potential (~0.38 V) and the highest current at low potentials. Electrodeposited samples exhibit superior overall performance due to better catalyst-substrate integration and improved conductivity. The electrode prepared at 120 min delivers the highest UOR activity. Notably, the best electrodes for both methods (24 h co-precipitation and 120 min electrodeposition) show similar activity at low current densities. However, the electrodeposited sample achieves higher current densities at increased potentials, indicating improved charge transfer and accessibility of active sites within the 3D Ni foam.

4. Conclusions - $Ni_2Fe(CN)_6$ Prussian Blue analogues significantly boost the electrochemical performance of Ni foam, particularly for the UOR, in which a marked reduction in onset potential and an increase in current density are observed. The optimized electrode (120 min deposition) exhibited enhanced UOR activity at low overpotentials, highlighting its potential for energy-efficient hydrogen production. These results demonstrate the relevance of electrode architecture and synthesis method in designing high-performance electrocatalysts.

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Enhanced Photocatalytic Hydrogen Production over TiO/g-C_3N_4/RuO_2 Ternary Heterojunctions

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Introduction - Among the several green energy sources, hydrogen (H2) stands out as an environmentally friendly, sustainable, and high-energy-density fuel [1]. Photocatalytic H2 production represents a promising approach for converting sustainable resources into clean chemical energy. In this context, the design of advanced photocatalytic materials with enhanced charge separation is crucial. Ternary heterojunctions promote interfacial charge transfer and suppress charge recombination, while suitable cocatalysts enhance charge separation, provide active sites for proton reduction, and reduce electron-hole recombination. Among the various cocatalysts investigated, ruthenium(IV) oxide (RuO2) has attracted considerable attention due to its excellent electrical conductivity, catalytic activity, and ability to facilitate interfacial charge transfer [2].

Experimental - In this study, different experimental parameters were investigated, including the RuO2 loading in binary TiO2/RuO2 and ternary TiO2/g-C3N4/RuO2 heterojunctions, and the influence of different sacrificial agents, namely triethanolamine (TEOA), methanol (MeOH), acetaminophen (ACT), and oxalic acid (OA). The structural, optical, and electronic properties of the prepared materials were characterized using various techniques. The photocatalytic performance of the most promising material was further evaluated in different aqueous matrices, including ultrapure water, wastewater, and river water.

Results and Discussion - The photocatalytic H2 production was strongly affected by both RuO2 loading and sacrificial agents. The highest H2 evolution was achieved for TiO2/RuO2(2.5 wt%), reaching 10501 µmol.g-1, while higher RuO_2 contents reduced the performance, suggesting excessive surface coverage and increased charge recombination. Ternary TiO2/g-C3N4/RuO2 heterojunctions exhibited significantly superior performance compared to the binary system (21893 µmol.g-1), confirming the beneficial role of g-C3N4 in enhancing charge separation. Among the sacrificial agents evaluated, the photocatalytic activity followed the order: TEOA > MeOH > OA > ACT, highlighting the superior hole-scavenging ability of TEOA. The optimal TEOA concentration found was 0.2 mol L-1 (22961 µmol.g-1), whereas a further increase caused a slight decrease in H2 production. The aqueous matrix also influenced the photocatalytic performance, following the order ultrapure water > river water > wastewater.

Conclusions - The TiO2/GCN/RuO2 ternary heterojunctions demonstrated significantly enhanced photocatalytic H2 production compared to the binary TiO2/RuO2 system, highlighting the synergistic effect of g-C3N4 and RuO2 on charge separation and interfacial charge transfer. The RuO2 loading and sacrificial agent strongly influenced the photocatalytic performance, with TiO2/g-C3N4/RuO2 (2.5 wt%) and TEOA showing the highest H2 evolution. In addition, the aqueous matrix affected the photocatalytic activity, with lower performance observed in river water and wastewater, which seems due to the presence of inorganic ions and organic matter. Control experiments confirmed the essential role of both light irradiation and the photocatalyst in H2 generation. Overall, the results demonstrate the potential of ternary heterojunction engineering as an effective strategy for sustainable light-driven H2 production.

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Solar-Driven CO2 Methanation via Photo-Thermal Catalysis Using Ru/TiO₂ Supported on Carbon Nanotubes

Supported on Carbon Nanotubes

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1. Introduction - The rising levels of carbon dioxide (CO_2) in the atmosphere have intensified interest in the development of carbon capture and utilization (CCU) technologies. Among these, the conversion of CO_2 into methane (CH4) using green hydrogen (H2) represents a promising route for renewable energy storage and greenhouse gas mitigation. While conventional thermocatalytic methanation requires high operating temperatures (400-600 °C), photo-thermal catalysis can utilize solar energy to drive the reaction at milder conditions, reducing the need for external heating. The combination of ruthenium (Ru) and titanium dioxide (TiO2) enables high photocatalytic activity under such conditions, benefiting from the synergistic effects of light and heat [1]. Furthermore, incorporating carbon nanotubes (CNTs) in the photocatalytic material can further enhance performance by improving charge transfer and surface area [2]. Accordingly, this work focuses on developing a Ru/TiO_2 photocatalyst supported on CNTs (Ru/TiO_2@CNTs) for efficient low-temperature photo-thermal CO_2 methanation.

2. Experimental - Solvothermal synthesis in ethylene glycol was employed to prepare the Ru/TiO_2 photocatalysts (10 wt.% Ru). This procedure included: (i) two-stage sonication-mixing (30 min of TiO2 suspension, followed by 30 min after Ru addition); (ii) in-autoclave reduction at 180 °C; (iii) twostage centrifugation for 20 + 20 min; and (iv) calcination at 350 °C for 3 h. In-autoclave reduction times of 5, 10, 15, and 30 h were tested to identify optimal conditions. The incorporation of 20 wt.% CNTs with the optimized material was assessed through five different strategies: (A) before Ru addition; (B) before reduction; (C) before calcination; and with calcinated Ru/TiO2 by (D) mechanical mixing via ball milling; or (E) ultrasonic mixing. The photo-thermal catalytic activity of the materials (100 mg) was evaluated in a 40 mL quartz batch reactor at 160 °C under simulated sunlight (1000 W·m-2, 280-3000 nm) using the stoichiometric [H2]:[CO2] molar ratio of 4:1 ([CO2]0 (13.5 mmol·L-1).

3. Results and Discussion - All Ru/TiO_2 photocatalysts demonstrated similar methane production rates (YCH4), except the 5-h catalyst, which showed 17-23% lower activity. Thus, the 10-h catalyst, achieving an average YCH4 of 7.2 ± 0.8 mmol·gcat-1·h-1, was selected as the base for CNTs addition. Among the Ru/TiO_2@CNT composites, all preparation methods except ultrasonic mixing (E) improved CH_4 production. While methods A, B, and C yielded similar enhancements, mechanical mixing via ball milling (D) delivered the most significant improvement, resulting in a 43% increase in YCH4 compared to the base material. In addition, all synthesized materials achieved 100% selectivity for CH4 production, with CO2 conversion efficiency above 45% within 20 min, and maintained stability across at least 6 successive cycles.

4. Conclusions - This research demonstrates that highly active and selective Ru/TiO2-based photocatalysts enable efficient solar-driven photothermal CO2 methanation under mild conditions. The incorporation of CNTs further boosts CH4 production, with mechanical mixing via ball milling proving the most effective strategy. These findings also highlight the potential to minimize external heating requirements, contributing to the overall sustainability of the process. This work reinforces the role of photo-thermal CCU as a strategic technology for achieving carbon neutrality, supporting sustainable fuel production that aligns with climate and energy transition goals.

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Rare earth elements in the environment and their extraction by microorganisms

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1. Introduction.

Rare earth elements are considered strategically important raw materials with wide applications in modern technologies, while their conventional extraction is often associated with environmental burden. Therefore, increasing attention is currently being paid to alternative approaches that could contribute to more environmentally friendly recovery of these elements. One of these possibilities is the use of microorganisms naturally occurring in metal-affected environments, which may exhibit the ability to interact with metals, including rare earth elements.

2. Results and Discussion.

We focused on the characterization of microbial communities present in selected environmental samples from metal-contaminated environments, the identification of selected bacterial isolates, and the evaluation of their potential for interaction with rare earth elements. For this purpose, cultivation-based, molecular, and metagenomic approaches were applied, as well as the analysis of the taxonomic composition of microbial communities, the identification of genes associated with metal resistance, and the experimental verification of the ability of selected isolates to interact with a model rare earth element [1]. Based on the analysis of 16S rRNA gene sequences, the selected isolates were identified as Priestia megaterium and Planomicrobium okeanokoites. The results showed that both tested isolates were able to reduce the concentration of yttrium in solution, indicating their ability to interact with this element. P. megaterium was able to reduce the yttrium concentration in the solution by 99.8% within 48 hours, and P. okeanokoites by 81.9% within 48 hours. P. megaterium has already been described as a microorganism with potential for the biosorption of metals such as zinc and cadmium [2].

3. Conclusions.

The obtained results may contribute to a better understanding of microbial communities in metal-impacted environments and to the assessment of their possible importance in the development of biological approaches aimed at the recovery of rare earth elements.

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Environmental challenges in urban aquatic ecosystems: patterns of pollution and ecological response

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1. Introduction – Urban aquatic ecosystems are increasingly vulnerable to the dual pressures of rapid urbanization and global environmental change [1]. The expansion of impervious surfaces and the removal of natural vegetation in big cities have fundamentally altered urban hydrological cycles, resulting in intensified surface runoff [2]. Urban runoff degrades water quality by washing surface oils, fertilizers from intensively cultivated urban green areas and heavy metals from roads and parking lots into reservoirs [3]. The primary ecological response to these stressors is accelerated eutrophication. High nutrient loading frequently triggers harmful algal blooms, which can produce toxins and create anoxic conditions leading to biodiversity loss [4]. These environmental challenges translate into significant public health risks and the loss of essential ecosystem services [5]. To mitigate these impacts, contemporary urban planning is shifting towards integrated water management strategies. Approaches such as the "Sponge City" concept and Green-Blue Infrastructure including the use of Nature-based Solutions aim to restore natural water cycles. Fundamental to addressing these ecological pressures are systematic monitoring actions, which serve as the indispensable basis for knowing and evaluating water quality [6]. Efficient and continuous surveillance is essential for the identification of potential health risks, the tracking of performance in improving environmental quality, and the informed formulation of pollution mitigation strategies [7].

2. Experimental - Water quality monitoring in urban city moat in Wrocław (Poland) was conducted at two sampling points over a multi-seasonal period (2024–2025). The dataset includes temperature, dissolved oxygen (DO), pH, and chlorophyll-a concentrations.

3. Results and Discussion - The results indicate persistent oxygen depletion, with DO concentrations frequently falling below ecologically safe thresholds (<5 mg/L), and periodic hypoxic conditions (<3 mg/L). These patterns coincide with elevated and highly variable chlorophyll-a concentrations, suggesting episodic phytoplankton blooms driven by nutrient enrichment. Significant pH fluctuations, ranging from neutral to strongly alkaline values (>9), further reflect intense primary production and shifts in carbon balance within the system. Seasonal increases in temperature amplify these processes by enhancing biological activity and reducing oxygen solubility.

4. Conclusions - The findings demonstrate that urban water bodies can function as highly dynamic and ecologically unstable systems, where nutrient enrichment and oxygen depletion are tightly coupled. This interplay leads to recurrent ecological stress, with potential consequences for biodiversity and ecosystem functioning. The study underscores the need for integrated management approaches, including nutrient load reduction and the implementation of nature-based solutions, to improve water quality and enhance the resilience of urban aquatic ecosystems.

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Grape Pomace Revolution: sustainable uses and waste management innovations

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1. Introduction

The winemaking process generates grape pomace (marc), consisting of stems, skins, pulp, and seeds left after pressing, representing 20-30% of processed grape weight (typically 30% stems, 30% seeds, 40% skins/pulp). EU Waste Framework Directive (2008/98/EC) prioritizes "waste prevention as primary focus, followed by reuse and material recycling over energy recovery"[1]. Traditional uses include alcoholic beverage production through fermentation/distillation (Greece, Italy,

Romania) and applications as animal feed or organic fertilizer. Innovative valorization approaches have emerged: grape pomace serves as sustainable wine fining agent due to natural compatibility for adsorbing unwanted phenolics/proteins; untreated/treated pomace removes water pollutants (pesticides, fungicides, metals, dyes); thermal treatment produces biochars supporting circular economy; its macro/micronutrients and antioxidant capacity enable functional food development (beef/pork burgers, chicken pâté, yogurt, ice cream, kefir, bakery products) [2]; incorporation into packaging films (chitosan, guar gum, starch, polypropylene) shows synergistic effects [3]; additional applications span biofuels (bioethanol, biohydrogen), cosmetics, and soil remediation. This study explores recent developments in grape pomace valorization across sectors, highlighting its transformation from waste to high-value material.

2,3 Results and conclusions

Grape pomace demonstrates versatile potential through conventional methods (distillates, animal feed, fertilizers) and innovative industrial applications (adsorption, food packaging, cosmetics, functional foods, bioenergy production). This comprehensive valorization aligns with EU waste hierarchy priorities, transforming winemaking by-product into sustainable economic assets while mitigating environmental impact (Fig. 1). Grape pomace valorization transforms winemaking waste into valuable raw materials (skins, fining agents, seed powders), supporting winery sustainability, circular economy principles, and EU waste hierarchy compliance. Fig. 1. The valorization of grape pomace and its use in a variety of industrial sectors

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Comparative Life Cycle Assessment of Diesel and Olive Stone Biomass

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1. Introduction - The intensive use of fossil fuels such as diesel poses significant environmental and sustainability challenges, promoting the search for renewable alternatives. In this context, biomass residues such as olive stones represent a promising solid biofuel due to their availability and renewable nature. This study aims to evaluate and compare the environmental impacts of conventional diesel and olive stone biomass using a Life Cycle Assessment (LCA) approach.

2. Materials and Methods - The study was conducted following the LCA methodology using SimaPro software, in accordance with ISO 14040 and 14044 standards. A cradle-to-gate approach was adopted to assess environmental impacts from raw material acquisition to fuel production. Two systems were defined: (i) conventional diesel production, modeled using processes available in the SimaPro database, including crude oil extraction, refining, and associated inputs such as water, hydrogen, catalysts, and energy consumption; and (ii) olive stone biomass processing, including biomass collection, transport, drying, and conditioning prior to its use as a solid biofuel. Impact assessment was carried out using the ReCiPe 2016 method (endpoint, hierarchical perspective), aggregating results into three damage categories: human health, ecosystems, and resources. The functional unit was defined as 1 kg of fuel to ensure comparability between systems.

3. Results and Discussion - The results show notable differences between the two systems. Olive stone biomass generally exhibits lower impacts in the resources category due to its renewable nature and reduced reliance on fossil inputs. In the human health category, impacts are primarily driven by emissions associated with biomass processing and combustion. Ecosystem impacts are limited, although sourcing and transport of biomass contribute modestly to environmental burdens. Overall, the analysis highlights the potential of olive stone biomass as a sustainable solid biofuel alternative to conventional fossil fuels.

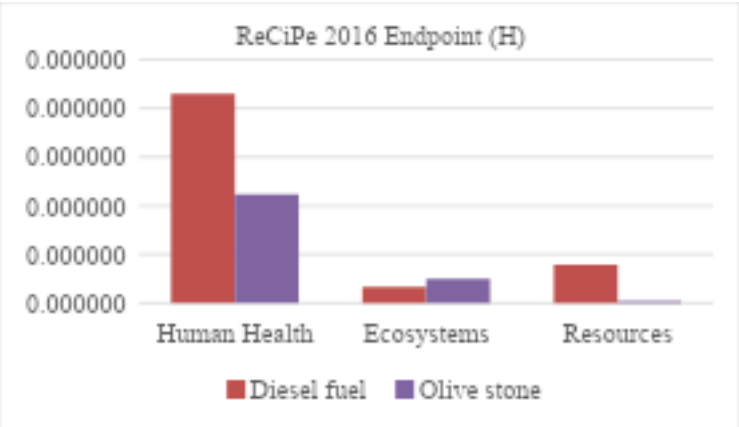

Image 1. Comparison of normalized impact results for Olive stone biomass and Diesel across the categories of human health, ecosystems, and resources.

4. Conclusions - Olive stone biomass represents a viable alternative to conventional diesel from an environmental perspective, particularly in terms of renewable resource use and waste valorization. Its utilization contributes to reducing fossil resource depletion and supports circular economy strategies. However, optimizing logistics, processing efficiency, and emission control is essential to enhance overall environmental performance. The application of LCA methodologies, such as ReCiPe 2016, provides a robust framework for supporting decision-making in the development of renewable energy alternatives.

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Synthesis of activated carbon from Arundo donax

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1. Introduction - Membrane bioreactors (MBR) combine biological and micro or ultrafiltration, which provide high quality effluents while reducing sludge generation. The main disadvantage of using MBR technology is membrane fouling, that is, the accumulation of particles, organic compounds or biofilms. This is a critical factor for the membranes as it reduces their efficiency. Membrane surface modification could offer solutions that increase resistance to fouling, reduce the need for cleaning and extend their lifetime. The modification of membrane surfaces with titanium dioxide (TiO2) stands out due to their self-cleaning effect, as TiO2 acts as a photocatalyst under UV light. Thus, it can decompose the organic matter adhered to the membrane surface under light, increasing its lifetime [1], although it can negatively affect the mechanical properties of the membrane [2].

2. Experimental - Membranes were synthesized mixing 1.968 g of cellulose acetate, 4.02 mL acetone, 4.98 mL N,N-dimethylformamide, x g of activated carbon (AC) and y g of TiO2, Aeroxide® P25. The materials were named xCAyTiO2. The flat sheet membranes were prepared in a TQC Sheen automatic film applicator equipped with temperature control and vacuum. They were characterized: BET (3P Instruments), pore diameter (Guerout-Elford-Ferry equation), rugosity (AFM Bruker, Multimode 8, Nanoscope V) and contact angle (Kyowa DMe-211Plus). SEM (Hitachi TM3030) images were taken. The membranes were tested using a synthetic wastewater with 1200 NTU and 120 mg·L-1 TOC. Membrane fouling was determined using the flux recovery ratio, FRR, calculated as the percentage of flux decline after the new membrane was fouled and cleaned.

Table I. FRR and TOC rejection results.

Membrane	FRR (%)	TOC rejection (%)
0CA0 TiO_2	97.09	17.5
0.3CA 0TiO_2	94.78	37.5
0.6CA 0TiO_2	94.83	33.4
0.3CA 2TiO_2	95.18	17.1

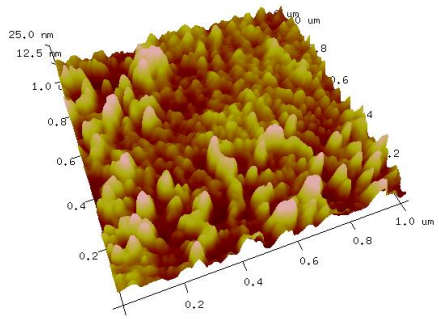

Image 1. AFM image of 0.3CA 2TiO_2.

3. Results and Discussion - All membranes depicted similar FRR values with high antifouling properties. The highest TOC rejection was achieved for 0.3CA 0TiO2, and the lowest for the membrane without CA and the one containing TiO2. All membranes achieved 100% turbidity rejection. The pore diameter of the modified membranes was calculated in the range of ultrafiltration (0.01 µm), except for 0CA0 TiO2 that was microfiltration (0.13 µm). The contact angle of 0.3CA TiO2 was lower, meaning higher hydrophilicity.

4. Conclusions - The membrane modified with 0.3CA 0TiO2 presented high FRR and the highest TOC rejection. The membrane containing TiO2 presented high FRR but deterioration was observed when it was irradiated with UV.

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Transformation of CDW into high value-added products using geopolymer technology

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1. Introduction - The European construction sector is a vital economic driver, accounting for 5.5% of the EU's GDP and employing 25 million people [1]. However, this importance comes with a significant environmental impact: the industry is responsible for 50% of resource extraction, 40% of energy consumption, and more than 30% of total waste in the EU [1]. To mitigate these effects, Regulation (EU) 2024/3110 [2] has been introduced, in line with the Circular

Economy Action Plan. This legal framework promotes the strategic management of construction and demolition waste (CDW), encouraging its recyclability from the design phase. In this context, geopolymer technology emerges as a sustainable alternative to traditional Portland cement, enabling the recovery of CDW as low-carbon precursors. This research explores the technical feasibility of transforming these waste streams into new cementitious materials through alkaline activation.

2. Experimental - The development of geopolymer structures was based on the recovery of construction and demolition waste (CDW), characterized by a high quartz content and an amorphous phase, but with a limited alumina (Al_2O_3) content, which required the use of additives to optimize the reaction. Three experimental groups (GP I, GP II, GP III) were evaluated to determine the optimal proportions of precursors and activators. The experimental design included: 1. Solid Precursors: A fixed base of RCD per mixture was used, supplemented with metakaolin (MK) to compensate for the alumina deficiency in the main waste and improve reactivity. 2. Residual Additives: Olive bone ash (OBA) was incorporated to evaluate its viability as an additive in the activating solution. 3. Activating Solution: A combination of sodium silicate (SS) and distilled water was used to control the Na_2O/SiO_2 molar ratio and the consistency of the paste. The specimens were formed by pouring into 3.5 cm cubic molds, applying a manual compaction and vibration process to ensure the removal of entrapped air, followed by controlled thermal curing.

3. Results and Discussion - The results obtained show that the partial substitution of natural precursors with CDW is technically feasible, although it presents rheological challenges. Analysis of the mixtures revealed that the incorporation of 10% metakaolin was critical for achieving structural stability, yielding a compressive strength of approximately 1.96 MPa in the base formulations at 28 days. While these values are modest compared to conventional Portland cement, they are sufficient for applications involving nonstructural elements and urban furniture with high geometric complexity. However, water absorption tests showed high values (above 40%), which is attributed to the high intrinsic porosity of the CDWs used, which contain a high proportion of ceramic-based material in their composition. These findings suggest that surface sealing treatment or optimization of the waste particle size distribution is required for applications in harsh outdoor environments.

4. Conclusions - This research validates the conversion of construction and demolition waste (CDW) into sustainable geopolymers through the strategic addition of metakaolin and residual ash from the combustion of olive pits. The conventional molding method yielded components with sufficient physical integrity for secondary building elements. It is concluded that, although porosity must be optimized for outdoor applications, this approach aligns with the sustainability requirements of Regulation (EU) 2024/3110, offering a viable solution for the circular economy in the construction sector.

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Synthesis of Losod zeolites from industrial sludge and comparison with the UiO-66 MOF using molecular simulation.

the UiO-66 MOF using molecular simulation.

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1. Introduction - This study evaluates the use of industrial sludges from granite (GCS), slate (SCS) and aggregate washing (AWS) as low-cost precursors for the synthesis of zeolitic materials, comparing their performance with the UiO-66 metal-organic framework (MOF) using a hybrid approach combining experimentation and molecular simulation. The experimental synthesis process involved acid pretreatment followed by alkaline fusion at 600 °C and hydrothermal crystallisation, resulting in the predominant formation of Losod-type zeolite (LOS) with a crystallinity of between 51% and 66%. CO_2 capture tests revealed reduced capacities for the synthesised zeolites (0.50-0.55 mmol/g) compared to the commercial reference 13X. In parallel, simulations were used to validate these results and compare them with UiO-66, determining that the closed-pore structure drastically limits the diffusion of the adsorbate compared to the open cages of the MOF. [1-5].

2. Experimental - The experimental phase began with the preparation of the GCS, SCS and AWS industrial sludges, which were dried at 105 °C and ground to a particle size of less than 63 µm. A pre-treatment with aqua regia was applied to minimise the iron content, followed by alkaline fusion by mixing the waste with NaOH in a ratio of 1:1.25 at 600 °C for 45 minutes. Hydrothermal crystallisation was carried out at 180 °C for 12 hours. For the comparative study of UiO-66, its activation was analysed via solvent exchange with methanol to release its ~0.8 nm micropores. Structural characterisation was performed using XRF, DRX with Rietveld refinement, FTIR and SEM-EDX. In the computational section, GCMC simulations with the TraPPE force field were employed to obtain CO_2 adsorption isotherms at various temperatures (298-343 K), using United Atom (UA) models to optimise computational efficiency. Diffusion kinetics were evaluated using MD, calculating the mean square displacement (MSD) via the Einstein equation.

3. Results and Discussion - Alkaline fusion induces the formation of Losod zeolite regardless of the residue used, with a significant amorphous fraction of between 33% and 43%. SEM analyses revealed hexagonal faceted structures typical of the LOS phase, whilst the FTIR spectrum identified T-O-T bands at 965-969 cm^{-1} and cancrinite units. In contrast, UiO-66 treated with methanol increased its surface area from 909 to 1339 m^2/g, raising its CO_2 capture capacity to ~3.7 mmol/g at 0 °C. Molecular simulation revealed that the low capacity of sludge zeolites is due to the LOS structure lacking open channels, which physically restricts the diffusion of CO_2 molecules. Furthermore, it was determined that the adsorbent's topology is the determining factor. Finally, process simulation suggests that the recycling of reagents can increase Element Utilisation Efficiency (EUE), improving the sustainability of the industrial production of these adsorbents.

Conclusions - It is technically feasible to convert sludge into zeolite phases, although the Losod structure limits CO_2 capture compared to UiO-66. The methodology determines the resulting topology; therefore, optimising waste-derived adsorbents requires structure-directing agents to create FAU-type open pores. The integration of molecular models and experimental data is essential for the sustainable design of carbon capture materials.

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135a · Poster Presentation | Poster Session WWEM-1 - Wednesday, 22 July 2026

National and European database for the characterisation and management of construction and demolition waste (CDW)

construction and demolition waste (CDW)

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1. Introduction - The main objective is to develop a national database of Construction and Demolition Waste (CDW) expanded with data at European level (Italy and Portugal). This tool aims to statistically link the characteristics of CDW with socio-economic variables, geological/geographical location and the type of value-added material that can be produced from it. The key benefits of this database include efficient data organisation, facilitated access and analysis, and improved information management, enabling informed decision-making to manage CDW efficiently and retain the value of resources within the system under a circular economy strategy.

2. Experimental - To build the database, a sequential process for sample preparation and characterisation was designed, comprising the 'Dry', 'Mill', and 'Coding and Labelling' phases. In the preliminary phase, a national and international sampling plan was established by contacting various associations and CDW plants in Spain, Portugal and Italy. Preliminary information on the plants was collected using forms gathering data on location, types of CDW (construction, demolition, renovation, roads), technology used and geological characteristics of the aggregate. A total of 124 plants in Spain and 6 in Portugal and Italy were contacted. The samples received were conditioned by drying at room temperature (72 hours) or in an oven, identified and tracked using QR codes, and subsequently crushed to particle sizes of 500 µm and <200 µm. Finally, analyses were carried out for particle size (Coulter), XRD, FRX, TOC and carbonates.

3. Results and Discussion - The compilation of information has enabled the creation of a geographical map of the participating CDW plants. Analysis of the statistical data obtained from the initial characterisation reveals high particle size heterogeneity, typical of unclassified CDW, where bimodal distributions are observed. At the correlational level (illustrated by heat maps), a strong positive relationship has been found between the amorphous material content and the mean particle size, indicating that the coarser fractions belong to materials that are poorly transformed or lack defined crystallisation. Similarly, there is a strong positive correlation between the percentage of calcite and particle size (presence of mortar or large limestone particles). Conversely, the percentage of quartz shows a negative correlation, indicating that particles with a higher quartz content (such as sand) tend to be finer.

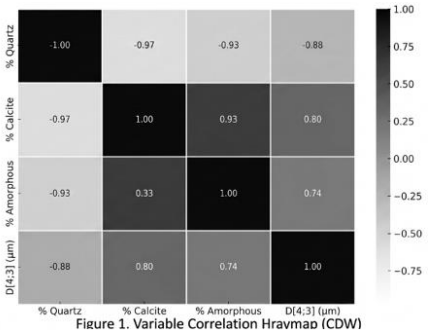

Figure 1. Variable Correlation Hravmap (CDW)

4. Conclusions - The creation of this comprehensive, standardised database provides a robust framework for classifying and predicting the suitability of construction and demolition waste. Statistically correlating geological origin, mineralogical composition and particle size distribution is essential for preassessing the viability of waste as secondary raw materials in the manufacture of new eco-products, proving to be a cornerstone in the construction sector's transition towards a circular economy.

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Towards full circularity: Thermal characterization of green composites made from 100% recycled polypropylene and post-consumer cellulose fibres

Towards full circularity: Thermal characterization of green
composites made from 100% recycled polypropylene and post-consumer cellulose fibres

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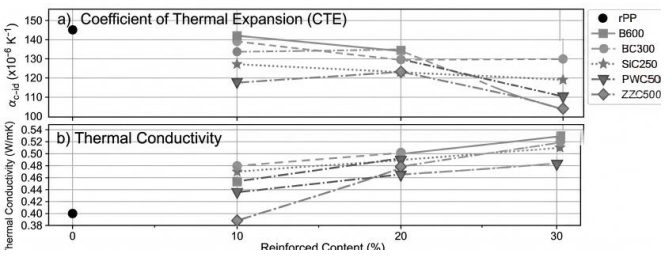
1. Introduction - The transition to a circular economy calls for sustainable alternatives to mitigate the environmental impact of fossil-based plastics, transforming waste into new, second-life raw materials. This study evaluates the development and thermal characterization of new high-performance green composites manufactured in a 100% circular manner, using a matrix of recycled polypropylene (rPP) and cellulose fibres derived from industrial and post-consumer waste, respectively. As previously documented, the incorporation of recovered cellulose fibres enables the development of materials with competitive mechanical performance for high-level industrial applications. Furthermore, understanding and optimizing the thermal parameters of these materials is vital for predicting the technical durability of components under real-world temperature cycles. Therefore, the main objective of this work is to determine how the exclusive inclusion of these recovered reinforcements influences the thermo-oxidative stability, phase transitions, dimensional stability and thermal conductivity of the new composite [1-3].

2. Experimental - For the polymer matrix, milled rPP derived from an industrial waste stream of household appliances was used, which contains 30% by weight of mineral fillers from its previous life cycle. Five types of cellulose fibres (virgin and recycled, notably the recovered ZZC500 and PWC500) were used as the reinforcing phase in proportions of 10%, 20% and 30% by weight. To ensure interfacial compatibility, 3% MAPP coupling agent (Licocene®) was added. The materials were mixed using corotating twin-screw extrusion (LAB-30, Useon) and the specimens were produced by injection moulding (Funac, Roboshot α-S50IA/330) under strictly controlled parameters. The evaluation of thermal behavior was carried out using thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), differential thermal analysis (DIL) and thermal conductivity measurements using the MTP methodology

3. Results and Discussion - Thermal tests reveal that the incorporation of reinforcing fibres slightly reduces the polymer's initial thermal stability by acting as catalysts for degradation. However, the simultaneous presence of the fibres and the MAPP promote a powerful nucleating effect, leading to a progressive increase in the matrix's degree of crystallinity with higher fibre loading. From a dimensional perspective, the fibres restrict the mobility of the macromolecular chains upon heating, significantly improving dimensional stability by reducing the material's coefficient of linear thermal expansion (α) by up to 28.9% for composites with higher reinforcement loading. Complementarily, the incorporation of fibres actively promotes heat conduction, increasing the composite's overall Image 1. Linear thermal expansion and thermal conductivity of thermal conductivity in direct proportion to the amount of composites reinforcement introduced (achieving increases of 32.7%), as illustrated in Figure 1.



4. Conclusions - The comprehensive analysis demonstrates that post-consumer recycled cellulose fibre (ZZC500) represents the most promising reinforcing material for ensuring full technical circularity. This reinforcing material induces optimal crystalline growth, resulting in a material with an excellent balance of properties: improved structural stiffness, high dimensional stability and optimized thermal conductivity for

heat dissipation in demanding industrial applications. In short, this research validates the technical feasibility of replacing virgin fossil-based plastics with 100% recovered eco-friendly alternatives.

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Acknowledgements

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Photocatalytic behaviour of hematite-rich waste: evaluation of support configurations and gas flow in accordance with ISO 22197-1

Photocatalytic behaviour of hematite-rich waste: evaluation of support

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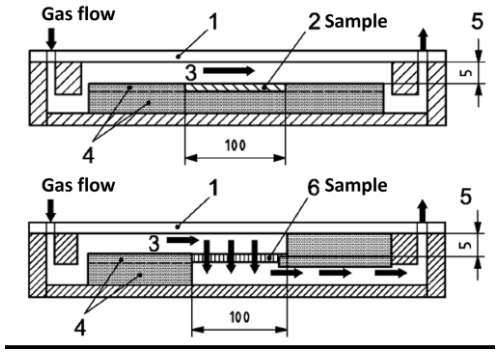
1. Introduction - Within the framework of the circular economy and industrial sustainability, the valorization of mining by-products and iron-rich waste represents a key strategy for reducing the environmental footprint. The use of hematite-rich waste (α-Fe2O3) for air purification not only minimizes waste accumulation but also transforms environmental liabilities into value-added materials. Although α-Fe2O3 is an active photocatalyst under visible light (1.9-2.2 eV) [1], its efficiency is often limited by the rapid recombination of charge carriers and a low pollutant adsorption rate [2]. The objective of this work is to evaluate the photocatalytic behavior through NOx removal using an adaptation of the ISO 22197-1 standard, comparing the efficiency between two gas flow configurations within the photocatalytic reactor using coated Figure 1: Gas flow configurations lightweight aggregates manufactured from waste studied based on ISO 22197-1 coated with hematite-rich residue (α-Fe2O3).



2. Experimental - For this study, a mining waste designated as DOF was used as a source of iron oxides. After being deposited as a coating onto lightweight aggregates, it was subjected to a thermal treatment at 600ºC to promote the mineralogical presence of hematite (α-Fe2O3) in its composition. Finally, the photocatalytic evaluation was carried out using the two gas flow configurations established in standard ISO 22197-1, introducing adaptations [3] to adjust the measurement to the materials under study.

3. Results and Discussion - The results should demonstrate whether there are significant differences in the NOx removal rate depending on the gas flow configuration used in the determination, shown both graphically as a function of time and in tabulated values quantifying the NOx removal rate

4. Conclusions - Previous results show that the DOF waste activated at 600ºC displays photocatalytic activity; therefore, based on the experiments carried out in this study, we aim to determine the most suitable measurement configuration for assessing the photocatalytic activity of spherical shapes, such as coated lightweight aggregates, since the standard specifies measurement for materials with flat surfaces.

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161a · Plenary Talk	Plenary, keynote and oral presentations - Thursday, 23 July 2026

Water reuse by Membrane Technologies. Research carried out in the Canary Islands

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Introduction - The Canary Islands currently rank fourth among Spain's autonomous communities in terms of the percentage of water that is reused from treated wastewater. These political and economic efforts have focused on producing treated water intended primarily for irrigating crops, gardens, and golf courses. Membrane bioreactor (MBR) technology has undergone significant development in recent years in the field of domestic wastewater treatment. This is evidenced by the large number of wastewater treatment and recovery plants that have adopted this technology, both nationally and internationally. However, new paradigms in treatment and recovery-centered on recovering all types of resources present in wastewater- as well as the need to make these facilities more sustainable and energy-efficient, have driven the development of new MBR systems capable of addressing these emerging concerns[1].

Results and Discussion - Since its creation in 1993, the Water Treatment and Reuse (TyRA) research group at the ULL has participated in and led several projects involving pilot and full-scale facilities related to Tenerife's wastewater reuse system. Over the past two decades, TyRA-ULL's research has focused primarily on membrane bioreactors (MBRs) with the aim of evaluating their feasibility, characterizing the fouling experienced by the membranes, and designing strategies to mitigate it. These studies have covered various types of membrane bioreactors: submerged anaerobic membranes, combinations of anaerobic and aerobic systems, and, finally, membrane photobioreactors (MPBR). This novel application of MBRs was initially studied for the recovery of nutrients from the effluents of anaerobic membrane bioreactors (AnMBR), with the aim of reducing the concentration of nitrogenous compounds that would limit their reuse for irrigation, due to their potential impact on groundwater as they infiltrate the soil and subsoil [2]. Recently, vertical closed-loop upflow MPBRs operated outdoors and using native microalgae (without inoculum) have been successfully commissioned. These MPBRs have been evaluated as a tertiary treatment for effluent from activated sludge treatment plants containing high concentrations of ammonium, which operate above their design capacity and lack nitrification-denitrification stages [3,4]. In the framework of TyRA-ULL studies, effluents from anaerobic moving-bed reactor (MPBR) systems have also proven to be an interesting culture medium for the growth of phototrophic species. Furthermore, our research has shown that microbial biodiversity helps mitigate membrane fouling, although the turbidity that these effluents may exhibit when used as a growth medium for phototrophic species is a limiting factor for light penetration and photosynthetic activity [5]. MPBR performance has been improved and optimized through various methods, such as dynamic optimization of filtration cycles, as well as the use of bioflocculated biomass at concentrations of up to 15.4 g/L [6]. To recover organic matter and nutrients from primary or direct ultrafiltration effluents, a rotating membrane prototype developed by TyRA-ULL (U201900257) has also been evaluated with optimal results.

In addition, recent studies have been focused on agronomic valorisation of the generated biomass as biofertilizer, biostimulant, and biofungicide, with promising results in corn [7], and this research is currently being expanded to new crops (lettuce and tomato).

Conclusions - MPBRs are a promising technology for removing emerging contaminants and producing high-value-added bioactive compounds from the resulting biomass, thereby expanding the paradigm and strategies for domestic wastewater treatment.

Acknowledgements - These studies were developed in the framework of PID2021-125404OB-I00 supportedd by MICIU/AEI/10.13039/501100011033/, FEDER/UE and RTI2018-093736-B-I00 (AEI 10.13039/501100011033 and by European Regional Development Fund (ERDF) "A way of making Europe", and collaboration by Consejo Insular de Aguas de Tenerife (CIATF), BALTEN and SACyR.

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126a · Keynote Talk	Plenary, keynote and oral presentations - Thursday, 23 July 2026

Analytical Challenges for Water Quality Control in Electrolysis Processes for Green Hydrogen Production

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Introduction

The large-scale deployment of green hydrogen production via water electrolysis is a cornerstone of current energy transition strategies. However, the performance, efficiency, and long-term durability of electrolysis systems strongly depend on the quality of the process water used (1). Trace-level inorganic and organic impurities, even at very low concentrations, can negatively impact electrolyzer efficiency, catalyst lifetime, membrane stability, and overall operational reliability.

Results

Different analytical strategies are discussed, including advanced chromatographic techniques, mass spectrometry, and spectroscopic methods, highlighting their advantages and limitations for routine monitoring and process control. The importance of method validation, traceability, and compliance with emerging quality standards for hydrogen production is also emphasized. Finally, this work underlines the need for integrated analytical approaches combining on-line, at-line, and laboratory-based techniques to ensure consistent water quality and support the sustainable and efficient production of green hydrogen

Conclusions

Robust and sensitive analytical control of water quality is essential to ensure the efficiency, durability, and reliability of green hydrogen electrolysis systems. Addressing trace-level impurities through validated and integrated analytical strategies is critical to support the scalable and sustainable deployment of green hydrogen technologies

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130a · Oral Presentation	Plenary, keynote and oral presentations - Thursday, 23 July 2026

Supercritical-CO_2 extraction for efficient recovery of wheat germ bioactives: enhancement of a pilot-scale process design

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1. Introduction - Supercritical carbon dioxide (SC-CO_2) extraction is a promising technology for sustainable industrial processing, enabling the selective recovery of high-value compounds using a nontoxic, non-flammable, and recyclable solvent. Compared to conventional solvent-based techniques, it reduces environmental impact and avoids energy-intensive downstream separation. However, industrial implementation remains limited due to operational instability and control complexity. This work addresses these challenges by focusing on process engineering and dynamic control strategies to improve the reliability and efficiency of a pilot-scale (50 L) SC-CO_2 extraction unit. Wheat germ, an agro-industrial by-product rich in bioactive compounds, was selected as model feedstock.

2. Experimental - Experiments were conducted on a batch pilot-scale SC-CO_2 extraction plant equipped with CO_2 recirculation. Wheat germ (15 kg per batch, 6% moisture) was processed without pretreatment. Extraction was performed at 260 bar and temperatures between 40-60 °C, corresponding to CO_2 densities of 800-900 kg·m^{-3}. A key modification was the installation of a subcooling heat exchanger upstream of the dosing pump to ensure liquid CO_2 feeding. Pressure stability was improved by tuning a pneumatically actuated back-pressure valve. Each extraction cycle lasted 5 hours with a CO_2 flow rate of ~100 kg·h^{-1}.

3. Results and Discussion - During initial operation, unstable pump performance occurred due to CO_2 conditions near vapor-liquid equilibrium, causing partial vapor formation and reduced volumetric efficiency. The installation of a specifically designed subcooling heat exchanger ensured fully liquid CO_2 at the pump inlet, improving start-up reliability, feed stability, and reducing mechanical stress. Pressure instability inside the extractor was identified as a major factor affecting solvent density and then extraction performance. Due to the non-linear behavior of supercritical CO_2, even small pressure fluctuations impact solubility and mass transfer. Dynamic tuning of the back-pressure valve (changing key parameters, such as dead band, correction time, output ramp) significantly reduced oscillations, ensuring a stable solvation environment. Extraction tests at 260 bar and 40-60 °C confirmed that CO_2 density governs extraction kinetics and yield. Higher densities enhanced solvent power, leading to a maximum oil recovery of ~6.9 wt% (Figure 1). Analytical characterization confirmed preservation of polyunsaturated fatty acids and α-tocopherol. Energy analysis showed that SC-CO_2 extraction has a comparable energy demand to hexane extraction, while offering advantages such as solvent elimination, absence of residues, and closed-loop operation (Figure 2). Despite higher capital costs, improved safety and reduced environmental impact support its industrial applicability.

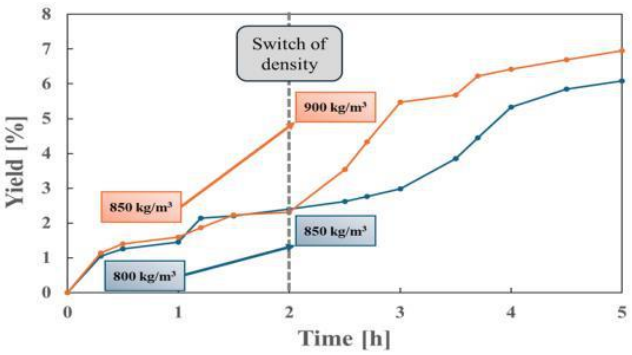

Figure 1. Extraction Yield vs Time.

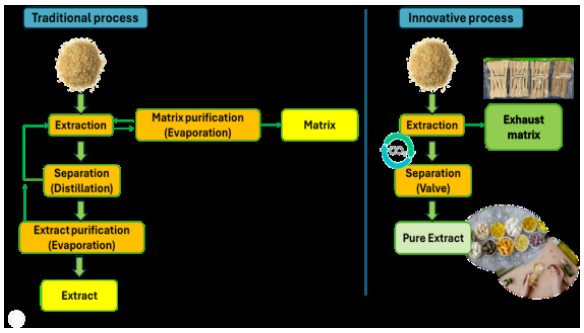

Figure 2. Comparison between conventional and SC-CO2 assisted extraction process.

4. Conclusions - This work demonstrates that pilot-scale SC-CO_2 extraction performance is governed not only by operating conditions but also by process stability and equipment design. Subcooling of CO_2 and dynamic pressure control are essential to ensure reliable operation. The optimized process achieves highquality extraction with competitive energy consumption and improved sustainability. These results provide practical guidelines for scaling up stable and efficient SC-CO_2 extraction systems for industrial applications.

171a · Keynote Talk	Plenary, keynote and oral presentations - Thursday, 23 July 2026

Strategies for water and wastewater treatment: carbon materials for adsorption, electrocatalysis and integration with AOPs

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1. Introduction

Water scarcity worldwide is leading society to develop water recovery strategies for proper water treatment and reuse [1]. Wastewater treatment plants often lead to inefficient removal of organic contaminants, since urban and industrial effluents are usually loaded with a complex mixture of inorganic salts and organic pollutants, which make their treatment a challenge using conventional technologies. In this context, carbon-based nanomaterials capable of promoting catalytic advanced oxidation processes (AOPs) are showing effectiveness for high-quality water recovery [3].

2. Experimental

This work will explore the development of different carbon materials, specifically graphitic carbon nitride and functionalised biochars (BCs), and their application for adsorption and electrocatalytic oxidation (as well as combination with other AOPs, such as catalytic wet peroxide oxidation (CWPO) or persulfate (PS) activation) of organic pollutants from different water matrices: surface waters, urban wastewaters and industrial wastewaters. BCs were prepared from wine industry residues under different thermal treatment conditions. Electrochemical operation parameters (electrodes, electrolyte type/concentration, pH, etc) were evaluated for different BCs in batch mode. The optimised carbon materials were then immobilised onto three-dimensional structures in order to operate in continuous mode. CWPO and PS were combined with the catalytic setups for both suspension electrode mode or immobilised packed-bed operation.

3. Results and Discussion

Control experiments demonstrated that individual processes, including direct anodic electrolysis, H2O2 or PS oxidation or the electro-activated BC alone allowed for relatively low removals of selected micropollutants. In contrast, the combined operation of BCs with oxidizing agents resulted in a substantial enhancement of the removal of these pollutants. The applicability of these processes under more realistic conditions was also evaluated using real river water and urban/industrial wastewater effluents, where the presence of various inorganic ions was found to facilitate the electro-based degradation process. Quenching experiments were conducted to determine the dominant oxidative species in these processes. In addition, reusability tests demonstrated the stability of BCs for electrocatalytic activation of PS. In terms of immobilised materials, long-term assay allowed to prove there is no loss of catalytic activity for CWPO.

4. Conclusions

The combined application of carbon materials with AOPs demonstrates the clear potential for the treatment of diverse surface waters and urban/industrial wastewaters. BCs were prepared by a facile method leading to electro-active suspended catalysts that can be coupled with H2O2 or PS activation, and easily immobilised onto three-dimensional supports. These results support the development of hybrid catalytic oxidation setups for advanced water and wastewater treatment.

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142a · Oral Presentation	Plenary, keynote and oral presentations - Thursday, 23 July 2026

Assessment of the technical feasibility of coffee waste as a raw material in the board industry

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1. Introduction - The Circular Economy model implies a new production and business modality in line with the economic growth of society, environmental sustainability and risk reduction due to the volatility and uncertainty of raw material and energy resource prices. The European Union is promoting the transition to a "recycling society" through the Circular Economy Action Plan, which aims to achieve "zero waste" by reducing and recovering waste. This transition requires that the manufacturing sector move away from the linear "extract-use-dispose" model toward an approach based on three pillars: waste reduction, keeping materials in use, and the regeneration of natural systems. Within this context, the use of waste to design new materials is a critical area of research. Coffee, the second most consumed beverage worldwide, with an estimated consumption of 300 kg/s, generates a massive amount of waste. Approximately 83% of the coffee beans used are turned into spent coffee grounds (SCG), classified under EWL (European Waste List) code 20 01 08. Nowadays, their disposal in landfills poses a significant environmental challenge. At the same time, global demand for particleboard reached 122,8 million m3 in 2024, with Europe accounting for one-third of that consumption. Given the high demand for wood and the chemical composition of SCG (27.08% de lignin and 38.50% cellulose), it emerges as a promising alternative. This study evaluates the technological feasibility of manufacturing particleboard using SCG as a raw material, thereby promoting its practical application on an industrial scale.

2. Experimental - Particleboard panels (280 x 280 x 10 mm) were manufactured by hot-press molding using a CARVER 4128 press. The optimal operating conditions were set at 160°C, a pressure of 2.5 MPa, and a time of 10 minutes. The mixtures contained SCG and wood particles (W), approximately 80% of which were recycled. Urea-formaldehyde (UF) was used as the binder for the core, and melamine-urea-formaldehyde (MUF) for the outer layers. Using a mixture design of experiments (DoE), 21 formulations were evaluated by varying the concentrations of W, SCG, and adhesives. Physical and mechanical characterization was performed in accordance with standard EN 312:2010. In addition, colorimetry and surface roughness were assessed. Finally, the ecological performance of the boards was evaluated using an LCA with SimaPro software 9.0.0.35 to verify the environmental viability of replacing virgin raw materials with waste and their contribution to the circular bioeconomy.

3. Results and Discussion - The influence of SCG content on the physical and mechanical properties of the panels was analyzed, and formulations were optimized to maximize the bio-residue content without compromising quality standards. The results indicate that, whilst an increase in SCG affects internal cohesion, the optimised model suggests the possibility of maintaining structural integrity compatible with certain requirements of commercial applications. Concurrently, the environmental sensitivity analysis identified SCG collection logistics as a critical point of impact. The optimal logistics radius was determined, within which bio-residue recovery offers a competitive advantage and a lower carbon footprint compared to wood sourcing and processing, thereby establishing a framework of geographic feasibility for the industrial implementation of this bioeconomy model.

4. Conclusions - The technical feasibility of manufacturing particleboard has been demonstrated by incorporating SCG at concentrations of up to 60% by mass to analyze its limits. While high concentrations affect bonding, the study identifies an optimized range that fulfils the structural requirements for P1-grade panels. An LCA analysis quantified an environmental credit based on reduced pressure on forest resources and a decrease in fossil fuel demand through optimized logistics and waste diversion. Ultimately, recovering SCG aligns with SDGs 9, 11, 12, and 13, positioning this post-consumer waste as a strategic resource for sustainable material diversification.

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165a · Oral Presentation	Plenary, keynote and oral presentations - Thursday, 23 July 2026

CREOSOLVE project - developing new biotechnological utilization methods for creosote-contaminated waste wood

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1. Introduction - Creosote-contaminated waste wood, including used railway sleepers, telecommunication poles and other impregnated wooden components, is a significant environmental and technological challenge. Creosote oil contains high concentrations of polycyclic aromatic hydrocarbons (PAHs), including carcinogenic compounds such as benzo(a)pyrene, which strongly limit conventional reuse or disposal pathways. Forecasts indicate that railway infrastructure modernization will generate approximately 1.1-1.5 million tonnes of used wooden sleepers in Poland and 12-16 million tonnes in Europe over the next two decades. Therefore, sustainable and scalable utilization methods are required to reduce environmental risks and support circular waste management.

2. Experimental - The CREOSOLVE project focused on the development and comparative evaluation of three innovative methods for treating creosote-contaminated waste wood. The first approach was a hybrid pyrolytic-biological method combining thermal pyrolysis of impregnated wood with subsequent microbiological degradation of pyrolysis-derived compounds. The second method involved bioremediation using selected microorganisms capable of degrading PAHs in a soil-based matrix. The third approach was based on composting, aimed at transforming contaminated wooden waste into a stabilized and environmentally safer product. The methods were assessed in terms of contaminant degradation efficiency, technological feasibility, operational requirements and environmental performance using life cycle assessment (LCA).

3. Results and Discussion - The obtained results confirmed that biological treatment routes offer high potential for the management of creosote-contaminated waste wood. Both the bioremediation and composting methods achieved degradation efficiencies exceeding 75%, which was defined as a key project target for creosote oil decomposition. These approaches also showed practical advantages related to relatively low operational complexity, lower environmental burden and potential scalability. In contrast, the hybrid pyrolytic-biological method was ultimately rejected due to insufficient efficiency and the highest environmental impact among the investigated scenarios, as indicated by the LCA results. The comparative assessment showed that methods based directly on biological degradation and composting are more promising than the combined thermal-biological pathway.

4. Conclusions - The CREOSOLVE project provides a scientific and technological basis for sustainable utilization of creosote-contaminated waste wood. The results indicate that bioremediation and composting can be effective alternatives to conventional thermal or physico-chemical treatment, achieving high contaminant removal while reducing environmental impacts. These findings support the implementation of environmental biotechnology in hazardous wood waste management and contribute to circular economy strategies focused on resource recovery and pollution reduction.

Acknowledgments

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Hydrochars from wet waste biomass and sewage sludge for the reduction of bitumen fume emissions

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1. Introduction - The valorization of wet waste biomass and sewage sludge is a relevant challenge within waste and wastewater management, due to their high moisture content, heterogeneous composition, and limited direct reuse options. Hydrothermal carbonization (HTC) is suitable for this purpose, as it allows wet feedstocks to be converted under subcritical water conditions into a carbon-rich solid product, named hydrochar, without requiring energy-intensive drying steps. Hydrochars have been mainly investigated as soil amendments, solid fuels, or adsorbents for aqueous-phase pollutants, whereas their use as functional additives for gas-phase emission mitigation is still less explored. This work investigates waste-derived hydrochars as sustainable additives for reducing volatile organic compound (VOC) and polycyclic aromatic hydrocarbon (PAH) emissions from bituminous materials. Hydrochars derived from HTC of an invasive aquatic biomass (Myriophyllum aquaticum) and sewage sludge have been investigated.

2. Experimental - HTC of Myriophyllum aquaticum was conducted in a 300 mL stirred stainless-steel reactor at 200 °C for 30 min and 25 wt% solid load. The recovered solid was filtered, washed, and dried at 105 °C for 12 h. HTC of sewage sludge was performed in the full-scale plant of Ingelia S.r.l. (Valencia, Spain). Both hydrochars were ground and incorporated into a 70/100 virgin bitumen (10 wt% by bitumen weight) using a high-shear mixer at 160 °C for 30 min. Emissions were analysed by headspace gas chromatography-mass spectrometry (HS-GC-MS) after heating the samples at 180 °C for 30 min. Compound identification was based on spectral libraries, while semi-quantitative evaluation was performed using toluene as reference compound.

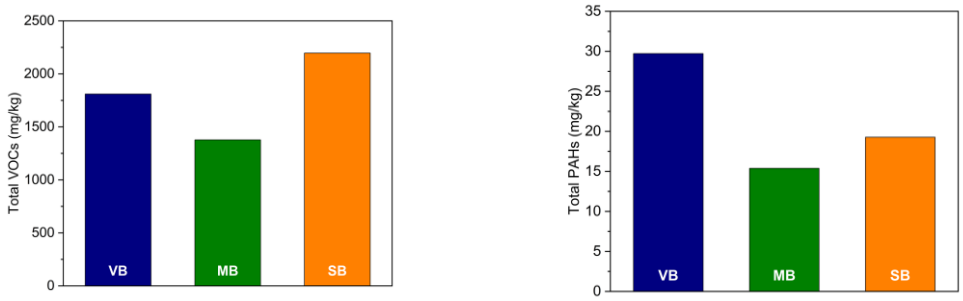

Image 1. Total VOCs (a) and total PAHs (b) emissions from virgin and hydrochar-modified bitumen.

3. Results and Discussion - The three bituminous binders, namely virgin bitumen (VB), M. aquaticum hydrochar-modified bitumen (MB), and sewage sludge hydrochar-modified bitumen (SB), were compared in terms of VOCs and PAHs profiles obtained by HS-GC-MS. As shown in Image 1a, MB showed a reduction of about 24 % in total VOC emissions compared with VB, consistent with the presence of a sorptive phase within the binder contributing to volatile species retention through pore filling, van der Waals forces, and π-π interactions with aromatic compounds. Conversely, SB showed an increase in the total VOC signal, suggesting that the sludge-derived hydrochar may promote both adsorption of specific compounds and release of volatile species under the adopted test conditions. A different behaviour was observed for PAHs (Image 1b). Both MB and SB showed lower total PAH emissions than VB, with reductions of about 48 and 35 %, respectively. The superior performance of MB may be related to the partially aromatized structure, higher porosity, and oxygen-containing surface functionalities of the M. aquaticum hydrochar, which can favour the adsorption and retention of volatile species.

4. Conclusions - This work demonstrates that HTC can convert wet waste biomass and sewage sludge into hydrochars suitable as functional additives in bituminous materials for VOCs and PAHs emission mitigation. The M. aquaticum hydrochar reduced both VOC and PAH emissions, while the sewage sludge hydrochar was mainly effective towards PAHs. Hydrochar origin strongly affected the emission reduction performance. These results support the valorization of wet residual streams into functional additives for lower-impact bituminous materials.

110a · Virtual Oral Presentation | Plenary, keynote and oral presentations - Thursday, 23 July 2026

Reducing Domestic Drinking Water Consumption through Greywater Reuse: A Sustainable Household Approach

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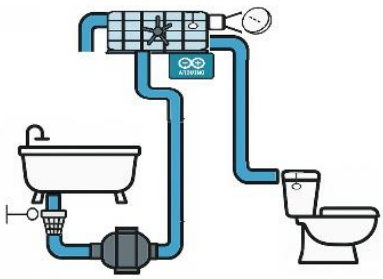
1. Introduction

Freshwater resources are increasingly under pressure due to climate change, population growth, and rising industrial and agricultural demand. Although water covers most of the Earth's surface, less than 1% is readily accessible for human use. Despite this limitation, drinking-quality water is widely used for non-potable purposes in households, such as toilet flushing and cleaning, resulting in inefficient resource utilization and increased stress on water supply and wastewater treatment systems. [1, 2] This study aims to evaluate domestic water use inefficiencies and present a decentralized greywater reuse solution to reduce potable water demand.

2. Method

The study combines analysis of domestic water consumption data with the design of a small-scale greywater recycling system. The proposed system collects lightly contaminated wastewater from showers and sinks, applies mechanical filtration and basic disinfection, and stores the treated water in a closed tank. The greywater is then reused for toilet flushing through a gravity-based distribution system.



System operation is controlled by a microcontroller (Arduino), integrating water level and flow sensors to ensure reliable and safe functionality. The design prioritizes low cost, simplicity, and adaptability for residential applications.

3. Results and Discussion

Average domestic water consumption in Hungary is approximately 95-100 litres per capita per day, significantly exceeding the ~50 litres required for basic needs. A large proportion of this consumption is related to toilet flushing, which does not require potable water quality.

The proposed system has the potential to reduce potable water use by approximately 15,000-18,000 litres per person annually. [3, 4] With an estimated implementation cost of 70,000-80,000 HUF, the solution is economically feasible and environmentally beneficial. Large-scale adoption could reduce demand on centralized water infrastructure and contribute to more sustainable water management practices.

4. Conclusion

Greywater reuse offers a practical and cost-effective approach to reducing unnecessary potable water consumption in households. The presented system demonstrates that significant water savings can be achieved with simple technological solutions. Broader implementation, supported by policy measures and increased awareness, could play a key role in addressing future water scarcity challenges and improving resource efficiency. [5]

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192a · Oral Presentation	Plenary, keynote and oral presentations - Thursday, 23 July 2026

Strategies for anaerobic valorisation of metalworking effluents: biostimulation and biochar addition

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1. Introduction

Metalworking degreasing effluents from the metal-mechanic industry are complex streams, often associated with high organic load, alkaline conditions, oils, greases and surfactants that may constrain direct biological treatment [1]. A possible valorisation route includes segregation and anaerobic treatment of these streams and may combine optimised organic matter removal with biomethane recovery [2]. However, this approach depends on the very complex effluent composition, biomass acclimation, organic loading control and strategies to mitigate inhibition [2-3]. This study assessed the anaerobic treatability of an alkaline degreasing effluent through a phased laboratory approach, combining batch tests evaluating food-to-microorganism (F/M) ratio and effect of addition of biochar of different particle sizes, as well as a semi-continuous biostimulation assay.

2. Experimental approach

The semi-continuous assay was conducted in a 5 L anaerobic reactor inoculated with sludge at 5 g VSS L^{-1} and operated under mesophilic conditions with a hydraulic retention time of 25 days. Biostimulation was promoted by gradually replacing glucose with degreasing effluent at substrate concentrations of 0.2 and 5 g sCOD L^{-1}. Batch assays were performed in respirometric equipment with the same inoculum concentration, testing F/M ratios from 0.02 to 1.00 g COD g^{-1} VSS supplemented with biochar (1 g L^{-1}; 0.5-1.0 and 1.0-2.0 mm). pH, sCOD, alkalinity, volatile fatty acids, solids and gas production were monitored.

3. Results and Discussion

In the biostimulation assay, the first stage confirmed tolerance under lower effluent incorporations, with sCOD removals of 71%, 64% and 56% at glucose:effluent sCOD ratios of 90:10, 70:30 and 50:50, respectively, whereas greater loads of effluent (30:70) led to null biogas production and no effective sCOD removal. After reactivation, the inoculum was submitted to 5 g sCOD L^{-1}, yielding sCOD removals of 83%, 65% and 46% at 80:20, 60:40 and 40:60 of glucose:effluent, while sustaining an average biogas production close to 0.25 L d^{-1}; however, high effluent loads (20:80) caused a progressive drop in sCOD removal and biogas production. As pH remained mostly neutral throughout the assay, the drop in reactor performance under high effluent concentrations was mainly associated with inhibitory or recalcitrance constraints rather than acidification or biomass washout alone.

In the batch assays, the anaerobic response depended on the initial substrate concentration and biochar particle size. In the control assays, sCOD removal ranged from 25% at 0.1 g COD L^{-1} to 63% at 5.0 g sCOD L^{-1}, while maximum specific methane production decreased with increasing load from 238 to 24 mL CH4 g-1 sCOD added, suggesting lower conversion efficiency under higher F/M ratios. Biochar supplementation yielded selective improvements: the 0.5-1.0 mm fraction enhanced biomethane production at 5.0 g sCOD L^{-1}, reaching 34 mL CH4 g-1 sCOD added (41% more than the control), whereas the 1.0-2.0 mm fraction favoured sCOD removals of 57% and 76% at 2.0 and 5.0 g COD L^{-1}, respectively.

4. Conclusions

Our approach showed that degreasing effluent from metalworking industry can be anaerobically valorised within a controlled operational window supported by gradual biomass acclimation and control of organic loading. Moreover biochar improved selected responses depending on particle size and concentration, indicating potential as a process-specific catalyst, although lacking in demonstration as a universal additive to anaerobic processes.

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143a · Poster Presentation | Poster Session WWEM-2 - Thursday, 23 July 2026

Multi-waste recovery for the production of active aggregates with fertilising properties

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1.Introduction - The transition towards a Circular Economy in the construction sector requires solutions that go beyond simple waste management. Whilst lightweight artificial aggregates (LWA) have already proven effective in reducing structural load and improving thermal insulation through the recovery of washing sludge (AWS) or construction and demolition waste (CDW) [1], this study proposes a paradigm shift: the Fertilising Lightweight Artificial Aggregate (LWA-F). This innovation not only incorporates industrial and municipal waste such as cork powder (CP), but transforms it into a slowrelease PK-fertiliser (SRF) through the incorporation of high-efficiency fertilising glass (FG) [2]. In this way, the aggregate ceases to be an inert component and becomes an active material capable of nourishing the environment, offering a comprehensive solution for green infrastructure and hydroponic systems that effectively closes the material cycle from industry to agronomy [3].

2. Experimental - For the development of LWA-F, a multi-waste approach was adopted, integrating four precursors: AWS, CDW from various geographical locations, CP as a pore-forming agent, and a highefficiency FG from glass cullet and specific by-products source in P and K. Three experimental series were formulated using CDW supplied by different waste management operators (ESM5, ESM7 and ITM3), incorporating 30% FG, and optimised to meet the macronutrient (P, K) requirements set out in European and national regulations. The manufacturing process consisted in the homogenisation of the mixtures, mechanical pelletisation and a sintering heat treatment in a rotary kiln at 1200 °C (4 min), following controlled preheating. Mechanical and physical characterisation included the determination of compressive strength (S), dry particle density (ρLd) and water absorption (WA24), whilst structural and chemical integrity was analysed using X-ray diffraction (XRD), X-ray fluorescence (XRF) and scanning electron microscopy (SEM). Functionality as a slow-release fertiliser was evaluated through systematic leaching tests (24 h to 28 d) in distilled water, citric acid (2% m/v) representing rhizospheric conditions, and acetic acid (0.5 M) simulating acidic rain.

3. Results and Discussion - The experimental results confirm the mechanical superiority of the ITM3 mixture, which achieved a compressive strength (S) of 12.1 MPa, whilst the ESM5 formulation stood out for its lightness with the lowest dry particle density (1.75 g/cm³). The low WA24 coefficients (4.6%-8.3%) corroborate the formation of a well-developed surface glass matrix that protects the integrity of the aggregate. Regarding its agronomic performance, leaching tests revealed that citric acid has a significantly higher extraction capacity due to its chelating properties than acetic acid, achieving a controlled release of up to 50% of phosphorus (P) and calcium (Ca) over a 28-day period. This behaviour is consistent with a gradual release mechanism stimulated by organic root exudates, which ensures the bioavailability of nutrients on demand by the plant. Finally, leachate analysis confirmed that concentrations of heavy metals (As, Pb, Hg) remain at trace levels, guaranteeing the safety and environmental soundness of LWA-F for use in urban ecosystems.

4. Conclusions - This study demonstrates the technical feasibility of manufacturing fertilising lightweight artificial aggregates (LWA-F) using a multi-waste approach. Whilst all the materials developed are effective as slow-release fertilisers and offer good nutrient availability, the ITM3 mixture stands out for having the best mechanical properties. This makes them an ideal option for green infrastructure and hydroponic systems, as they combine structural strength with an efficient supply of nutrients to plants.

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Removal of 17β-Estradiol using activated carbons derived from plastic waste: Analytical methodology and adsorption studies

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1. Introduction - Nowadays there is growing evidence that endocrine-disrupting compounds (EDCs) can have harmful effects on aquatic organisms and even human body. EDCs can be directly or indirectly discharged into the aquatic environment. Among the ED compounds with the highest estrogenic activity are both the natural estrogens (e.g. 17β-estradiol and estrone) and synthetic estrogens, such as 17α-ethinylestradiol. Wastewater treatment plants appear to be a major pollution source, as these compounds are not completely removed or degraded by the conventional biological treatment processes [1]. On the other hand, various analytical methods have been developed to accurately analyse EDCs in wastewater matrices. The most commonly used analytical equipment are liquid or gas chromatography (LC/MC) coupled with mass spectrometry (MS). Thus, the aim of this work is the development of an analytical methodology that enables the detection and quantification of the female sex steroid hormone 17β-estradiol (E2) in both ultrapure water and real aqueous matrices, thereby allowing its concentration in wastewater to be monitored. This contaminant acts as an endocrine disruptor and typically has low solubility in water; therefore, different solvents are usually used for its determination. In this work, ethyl acetate was used as the organic solvent. In addition, and in order to explore alternatives for the efficient removal of 17β-estradiol from wastewater matrices, an activated carbon synthesized from polyethylene terephthalate (PET) waste via chemical activation was used to accomplish adsorption kinetic studies.

2. Experimental - A series of analyses have been carried out, enabling the validation of the analytical method using a gas chromatograph coupled to a mass detector (Agilent 6890N and MSD 5973N). Three miniaturised extraction processes (500 µl sample volume) were tested: liquid-liquid extraction using 500 µl of ethyl acetate (EtOAc), with the addition of NaCl to promote phase separation, followed by evaporation under a stream of N2 at 40°C and subsequent reconstitution of the sample in ethyl acetate. The samples were then derivatised using different silylating agents, such as “MTBSTFA+TMCS” and “BSA+TMCS”, obtaining better results for BSA+TMCS, following incubation at 70ºC for 30 min.

3. Results and Discussion - A high degree of reproducibility has been obtained, with high recoveries (90%), a wide linear working range (10-1000 µg/L) and low limits of detection. Thus, using this analytical method, 17β-estradiol has been detected in both ultrapure water as well as real-world aqueous matrices, at both low and high concentrations. Then, this analytical method has been successfully applied to the monitoring and treatment of this hormone in quaternary effluents using adsorption processes.

4. Conclusions - In this study an analytical methodology that enables the monitoring of the waterborne contaminant 17β-estradiol using GC-MS techniques has been developed. Then, to evaluate the removal of this compound from aqueous matrices, adsorption kinetic studies using an activated carbon synthesized from plastic waste were accomplished, finding satisfactory removal results.

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157a · Poster Presentation | Poster Session WWEM-2 - Thursday, 23 July 2026

Sustainable carbon adsorbents from plastic waste: Comparative studies of synthesized activated carbons for BPA removal

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1. Introduction - Plastic pollution is a worldwide problem, and it is essential to highlight that a significant proportion of plastic waste is rarely recycled [1]. The fast pyrolysis method offers a solution, using a thermo-chemical process that converts un-recycled plastic waste into oil, gas and char as by-products. Although the oil and gas are widely used, char has been considered a waste product and its uses have been restricted due to its low porosity, lower specific surface area and high activation costs. In this sense, there are very few literature reports focused on lab scale studies using activated carbons derived from plastic waste and its application in wastewater treatment [2]. Bisphenol A (BPA), the most widely studied endocrine-disrupting compound to date, is still being detected in wastewater treatment plants effluents worldwide at concentrations ranging from a few ng/L to hundreds µg/L [3]. The aim of this work is to evaluate the removal of BPA from water using activated carbons synthesized from polyethylene terephthalate (PET) wastes.

2. Experimental - Activated carbons were synthesized using PET plastic waste as precursor, one via physical activation with CO_2 (PAC - microporous), and the other via chemical activation using KOH as activating agent (CAC - micro-mesoporous). In order to obtain the equilibrium time and the equilibrium adsorption capacity for BPA, both adsorption kinetic and equilibrium isotherms were obtained in an orbital shaker at constant temperature (±30 ºC) and stirring (250 rpm), and using an adsorbent dose range of 0.012-2.5 g L^{-1} and an initial BPA concentration of 20 mg L^{-1}.

3. Results and Discussion - The obtained adsorption isotherms showed that CAC activated exhibited the best adsorptive performance, with a BPA equilibrium adsorption capacity (qe) value of 400 mg·g^{-1}, compared to the adsorption capacity obtained for CO_2-activated carbon (PAC) (qe = 49.6 mg·g^{-1}). These differences can be attributed, among other factors, to the high porosity development-a large proportion of micropores and mesopores-shown by CAC carbon (SBET = 1349 m^2 g^{-1}, Vmicro = 0.40 cm^3·g^{-1}, Vmeso = 0.96 cm^3 g^{-1}); compared to the less favorable textural properties shown by PAC (SBET = 1025 m^2 g^{-1}, Vmicro = 0.42 cm^3·g^{-1}, Vmeso = 0.06 cm^3 g^{-1}). From these data, it can be observed that PAC activated carbon has not mesoporous structure, limiting the access of BPA molecules to the inner porosity of the adsorbent. In this regard, CAC activated carbon led to a faster adsorption kinetics (equilibrium time of 25 h) and much higher adsorption capacity than PAC carbon.

4. Conclusions - In this work, it could be observed that the activated carbon synthesized by chemical activation with KOH (CAC) showed excellent textural properties, leading to a fast adsorption kinetic as well as to a very high equilibrium adsorption capacity. So, this kind of material can be considered a good candidate to be used in tertiary wastewater treatment processes for the efficient removal of emerging contaminants.

Acknowledgments. This work has been supported by the MCIN PID2023-150365OB-I00, funded by the MCIN/AEI/10.13039/501100011033, and the European Union Next Generation EU/PRTR programme. L. Rodríguez Arranz would like to thank the Ministry of Science, Innovation and Universities for awarding her pre-doctoral contract for doctoral thesis (PREP2023-001682).

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Two-stage bioconversion of whey using Tetradesmus obliquus and fluorescent Pseudomonas spp. bacteria for potential frost protection applications

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1. Introduction.

Frost damage represents a major challenge in agriculture, causing significant reductions in crop productivity and quality. Microorganisms capable of producing ice-interacting extracellular compounds have gained increasing attention as potential biological frost protection agents [1,2]. The present study investigates the cultivation of bacteria belonging to the Pseudomonas fluorescens group bacteria in cheese whey medium for evaluation of potential antifreeze activity. As cheese whey is a major dairy industry by-product characterized by high lactose concentration and elevated organic load, creating significant environmental disposal challenges [3]. Microalga T. obliquus MSCL 1710 was used to improve substrate suitability for bacteria belonging to the Pseudomonas fluorescens group bacteria, which exhibit limited lactose utilization capacity and have been associated with ice-interacting extracellular compounds [1,2].

2. Experimental.

Microalga T. obliquus was cultivated in sterile 50% concentration cheese whey medium for 10 days at 28℃, with the concentration selected on basis of a previous optimization study [5]. After the microalgal biomass separation, the resulting cultural liquid was used as a medium for further bacterial cultivation. Changes in lactose, glucose, galactose, and protein concentrations in the medium were monitored throughout the stages of the process. Biomass composition of T. obliquus was additionally determined. Potential antifreeze activity of bacterial cultures collected after 24 h, 48 h, and 72 h was evaluated using a modified droplet freezing assay at −10 °C.

3. Results and Discussion.

Microalgal cultivation reduced lactose concentration from 24.2 to 11.85 g L^{-1} and increased glucose and galactose concentrations from 0.13 to 0.55 g L^{-1} and from 0.15 to 0.67 g L^{-1}, respectively. Subsequent bacterial cultivation resulted in near-complete utilization of glucose and galactose, supporting bacterial growth up to 1.1 x 109 CFU mL^{-1} after 72 h cultivation. Protein concentrations decreased by approximately 66% during the sequential treatment process. The produced T. obliquus biomass contained in average 12.7% proteins, 8.9% lipids, and 61% carbohydrates indicating additional whey valorisation potential. In a similar way, microalgae- and microalgae-fungi whey-based cultivation systems have demonstrated efficient nutrient conversion and biomass generation [4,6]. As shown in our study, several bacterial cultures exhibited delayed freezing behaviour at −10 °C compared to control samples, indicating the presence of extracellular metabolites associated with antifreeze activity [1,7]. Similarly, ice-interacting compounds have previously been identified in Pseudomonas spp. associated with plant environments [1,7]. The strongest freezing resistance was observed in samples collected after 24 h cultivation.

4. Conclusion.

The obtained results demonstrate the potential of Pseudomonas fluorescens group bacteria cultivated in whey derived medium to produce metabolites associated with frost protection activity. The two-stage microalgal-bacterial cultivation strategy enables nutrient conversion and whey valorisation option, supporting development of sustainable biotechnological approaches for agricultural applications.

Acknowledgement This study was co-financed by European Agricultural Fund for Rural Development (EAFRD) and supported by the Ministry of Agriculture and Rural Support Service of the Republic of Latvia, grant Nr. 25-00-C0LA1602-000005.

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Preliminary assessment of a rotating hollow-fiber membrane for MPBR biomass dewatering

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1. Introduction - As regulations become stricter with time, wastewater treatment plants (WWTP) must advance towards more efficient technologies to comply with European regulation [1]. This is especially challenging in small territories where land availability is limited, favoring intensive technologies over large WWTPs. The use of membrane photobioreactors (MPBR) seems promising as a treatment alternative in area-limited territories, since they can achieve both water reclamation and biomass production. In these cases, the harvesting of biosolids in the MPBR is a necessary step before making use of the valuable products that can be obtained from the biomass [2]. This study aims to assess the use of a rotating, hollow-fiber ultrafiltration membrane module for the dewatering of the biomass with the goal of concentrating the solids prior to its application for other uses.

2. Experimental - The biomass used was obtained from an outdoor, pilot-scale MPBR facility located in Santa Cruz de Tenerife, Spain. This plant is fed with the secondary effluent from a domestic WWTP and has a stable culture composed of naturally-occurring microorganisms, predominantly green algae and cyanobacteria. The dewatering unit consists of a ZeeWeed-1 (ZW-1) hollow-fiber membrane ultrafiltration module (GE, USA), connected to an overhead stirrer (Heidolph, Germany) that allows to control the rotation speed (w). The experiments included a preliminary short-term flux-step trial to determine the critical flux (Jc) and fouling rate (rf) at four different rotation speeds (0, 45, 90 and 180 rpm). Then, a biomass dewatering step was performed at Jc for each of the rotational speeds evaluated. After the dewatering, the concentrated biomass was left to settle for 30 minutes, after which samples of both the supernatant and the biosolids were collected separately. In addition, the pre-dewatering biomass and the filtered effluent were analyzed. The samples were assayed for pH, electrical conductivity, turbidity, viscosity, TSS, total and soluble COD, DOC and DIC (Dissolved Organic/Inorganic Carbon, respectively). Furthermore, both fluorescence spectroscopy and colorimetric methods were used to measure extracellular polymeric substances (EPS) concentration.

3. Results and Discussion - The flux-step trials showed a clear difference between the control experiment (w = 0 rpm) and the tests performed in the presence of rotation. As expected, in the absence of shear-stress the results showed a marked exponential increase in r f, with trends that separated from the other trials' trends as soon as J = 16 LMH - going in increments of 2 LMH, from 6 to 50 LMH. For the trials carried out at w values of 45, 90, and 180 rpm, rf increased more gradually, indicating that the turbulence generated by the rotation of the ZW-1 module effectively mitigated membrane fouling for a given biomass. While the 45-rpm trial showed slightly higher rf values than the 90 and 180-rpm trials, the difference does not appear to be significant enough to justify using higher rotation speeds, resulting in higher energy demands for the process. Across all dewatering phases, the harvested biomass showed a noticeable increase in turbidity, TSS and total COD. For these parameters, there was a 5-fold increase on average, meaning the biomass can be five times as concentrated using the proposed setup. Neither soluble COD nor DOC changed significantly before and after concentration, which could indicate that the tested rotation speeds do not cause cell breakdown, avoiding the subsequent release of soluble microbial products. Observing the different excitationemission matrices, it was found that the permeate samples had signals half as intense as those in the supernatant samples, meaning that the ZW-1 module can concentrate EPS in the dewatered suspension.

4. Conclusions - The dewatering of algal-bacterial biomass using a hollow-fiber membrane module appears to be improved through the introduction of rotation, switching from an exponential trend at w = 0 rpm to a more gradual increase with w values as low as 45 rpm. At the tested rotational speeds, the membrane module was able to concentrate the biomass, avoiding apparent losses to the permeate.

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Spatio-temporal distribution of marine litter in two tropical estuaries on Northeast Brazil (7°S)

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1. Introduction - Marine litter is widely distributed in oceanic, marine, and coastal ecosystems1,2,3,4. Estuarine ecosystems serve as breeding and nursery grounds for several fish and invertebrate species, and are often located in densely human-populated regions and, therefore, suffer from a high load of marine debris, particularly plastic4. Actually, plastic is the most common type of marine litter due to its durability and widespread use in various sectors of society. The aim of this study was to analyze the abundance of marine litter in two Brazilian tropical estuaries subjected to different degrees of anthropogenic impact.

2. Methodology - The study was conducted in the estuaries of the Paraíba and Mamanguape rivers, in the Paraíba State, Northeast Brazil (7°S). The former is highly impacted due to massive human occupation, while the latter is an environmental protected area. Collections took place at three stations in each estuary during the beginning of the rainy season in 2020, 2021, and 2022. In addition, quarterly campaigns were carried out throughout 2021. At each point, three trawls were performed perpendicular to the estuarine margin, totaling 108 samples (54 on each estuary).

3. Results and Discussion - Marine litter was found in 66.6 and 9.6% of the samples from Paraíba River estuary (PRE) and Mamanguape River estuary (MRE), respectively. In both estuaries studied plastic dominated, representing 95% of the litter collected. Most of the plastic found was categorized as disposable, including food packaging, cups, and bags. Significantly ($p<0.05$; ANOVA) higher amounts of marine litter were found in the PRE, averaging 157.7 ± 202.4 items/ha, while in the Mamanguape River estuary (MRE) values were typically <10 items/ha. The abundance of litter peaked during periods with higher tourist activities and rainfall. Comparing the three years evaluated, significantly ($p<0.05$; ANOVA) higher values were observed in 2022 in both estuaries. These differences are likely to be related to the COVID-19 pandemic, and in 2020 and 2021 there were few people circulating due to a strong lock-down. MRE and PRE clearly had different levels of litter pollution, as expected, considering the different levels of urbanization and human occupation around them. The high dominance of plastic and the temporal fluctuations associated with rainfall and touristic activities is consistent with studies conducted in other estuaries worldwide4. Plastics are known to pose a great treat to marine organisms both through ingestion and entanglement, influencing several biological aspects, including growth, metabolism, behavior, and feeding, and can lead to population decrease and diversity loss1. Considering both estuaries harbor a high diversity of both fish and invertebrates, and have great socioeconomic importance, the high pollution levels found, particularly of plastics, require attention.

4. Conclusion - The degree of marine litter pollution in the estuaries studied is quite different, and reflects human impact and a lack of effective waste management policies particularly in the PRE. To mitigate this problem, it is essential to implement measures such as environmental education, the creation of specific laws to reduce the use of disposable plastics, and the promotion of sustainable alternatives, aiming to protect these estuarine ecosystems that are important for biodiversity and the local economy.

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Advanced Oxidation Processes for E. coli Inactivation in Different Aqueous Matrices: A Comparative Study

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1.Introduction - Wastewater and surface waters contain bacteria that seriously pollute and harm human health. They include Campylobacter jejuni, Vibrio cholerae, Vibrio comma, Escherichia coli, Gerus, and Shigella (flexneri, sonnei, boydii, dysenteriae). Also, Typhoid fever, Salmonella typhosa, and Salmonella paratyphi. Of all the pathogens above, E. coli is considered a key marker [1]. Advanced oxidation processes (AOPs) have emerged as promising alternatives. These processes generate highly reactive oxygen species (ROS), such as hydroxyl radicals, capable of breaking down a wide range of biological pollutants [2]. This study focused on the comparative disinfection of Escherichia coli (E. coli) in two distinct water matrices: ultrapure water (UPW) and wastewater treatment plant (WWTP) effluent, considering kinetics, mineralization, and energy consumption. The advanced oxidation processes (AOPs) evaluated included ultraviolet radiation (UV), electrooxidation (EO), ultrasound cavitation (US), and ozone (O_3). Each process was applied both individually and in combination (HAOP).

2. Experimental - The reactor used in this experimental study is described in detail in patent [3].

3.Results and Discussion - This study shows that HAOP performance for E. coli inactivation is higher in ultrapure water than in WWTP effluent due to matrix complexity and scavenging effects. Ozone-based processes were the most effective in both matrices, achieving the highest disinfection and mineralization efficiencies. In complex effluents, differences between treatments were less pronounced, although ozone systems remained dominant. Energy analysis identified simple ozonation as the most cost-effective option, while UV/O_3 provided the best balance between efficiency and practicality for wastewater treatment.

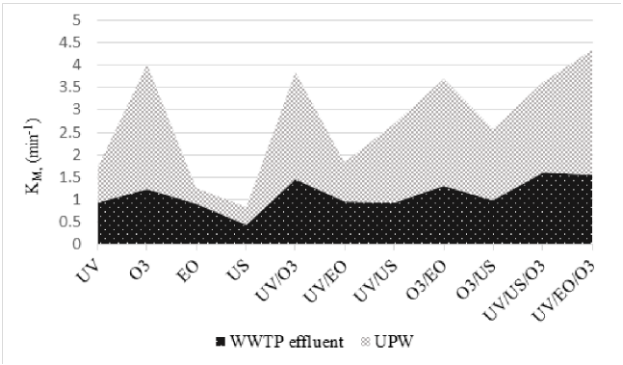
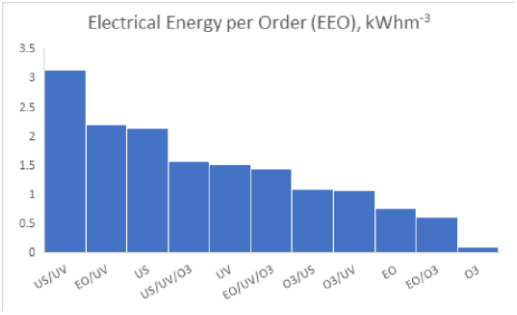


Figure 1. Effect of the aqueous matrix on disinfection kinetics.



4.Conclusions - This study shows that HAOP performance for E. coli inactivation

Figure 2. Effect of the aqueous matrix on

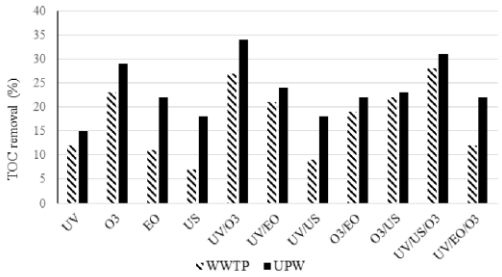


Figure 3. Energy efficiency of individual and combined processes in WWTP effluent.

is higher in ultrapure water than in WWTP effluent due to matrix complexity and scavenging effects. Ozone-based processes were the most effective in both matrices, achieving the highest disinfection and mineralization efficiencies. In complex effluents, differences between treatments were less pronounced, although ozone systems remained dominant. Energy analysis identified simple ozonation as the most cost-effective option, while UV/O_3 provided the best balance between efficiency and practicality for wastewater treatment.

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Optimizing Azole pollutants removal by CCORD design using coupled Electrooxidation + UV advanced process

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1.Introduction - Azole fungicides are commonly used in agriculture and horticulture, known for their persistence and biological activity at low concentrations, which complicates removal through conventional treatments. These compounds have been detected in surface waters, wastewater effluents, and occasionally in drinking water, at concentrations ranging from ng·L-1 to µg·L-1 [1]. Additionally, some azole transformation products (TPs) [2] may retain endocrine or antimicrobial properties, requiring advanced treatment methods. After use, fungicides are transported to wastewater treatment plants, where complete removal is not achievable. In response, the European Commission adopted Decision (EU) 2022/1307, establishing a watch list of substances for EU-wide water monitoring, including penconazole (PNZ), prochloraz (PCZ), tebuconazole (TBZ), and tetraconazole (TCZ).This study aimed to optimize the removal of azole compounds using the coupled process of Electrochemical Oxidation (EO) and Photolysis (UV) with the Central Composite Orthogonal and Rotatable Design (CCORD).

2. Experimental - The reactor used in this study [3] features a low-pressure mercury vapor lamp as the radiation source. The electrochemical system includes a boron-doped diamond (BDD) anode and a stainless-steel cathode. Galvanostatic conditions are applied using a Tektronix power supply, and sodium sulfate in water serves as the supporting electrolyte.

3.Results and Discussion -

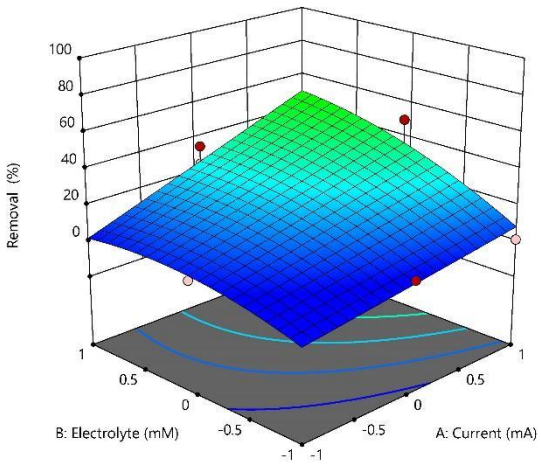

Figure 1. Influence of Electrolyte and Current Density on the EO Process.

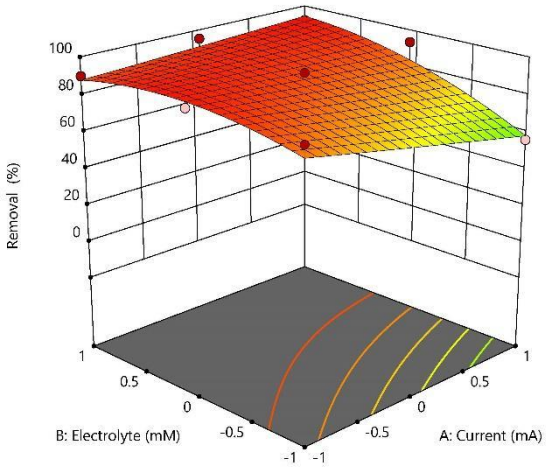

Figure 2. Influence of Electrolyte and Current Density on the EO-UV Process

4.Conclusions - A significant difference is observed upon inclusion of ultraviolet radiation in the removal process of azole compounds. The analysis reveals the critical process parameters for effective EO-UV removal of azole fungicides. For the EO-UV process: at low electrolyte concentrations, the influence of current density is slightly negative, whereas at high electrolyte concentrations, the influence of current density is slightly positive.

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Techno-economic assessment of synergies between green hydrogen production and wastewater treatment via oxygen valorization

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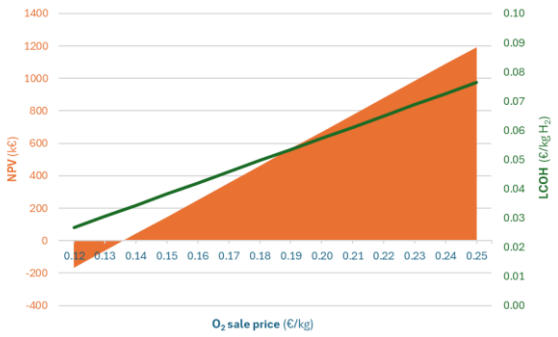
1. Introduction - Within the Horizon Europe project H2tALENT [1], green hydrogen deployment in Sines industrial cluster (Alentejo, Portugal) is evaluated through cross-sectoral integration strategies. Water electrolysis produces high-purity oxygen (O2) as an intrinsic co-product, which is typically vented despite its valorization potential. This study assesses the techno-economic feasibility of supplying electrolytic O2 to a nearby wastewater treatment plant (WWTP) that currently relies on supplemental pure-O2 to stabilize activated sludge treatment under high and variable loading conditions.

2. Experimental - An annual consumption of 840 t O2/y is assumed, supplied to the WWTP as high purity (≥99.95 %) liquid oxygen (LOX). The planned alkaline electrolyzer, located ~2.5 km from the plant, enables potential gaseous O2 delivery via a short-distance, low-pressure pipeline. The base-case analysis considers additional CAPEX (0.9 M€) and distribution OPEX (0.05 €/kg O2) from the hydrogen developer's perspective. Avoided LOX prices of 0.15-0.25 €/kg O2 are assumed [2]. Economic performance is evaluated using payback time, net present value (NPV, 20 years, 5 % discount rate) and impact on the levelised cost of hydrogen (LCOH). A second case study explores the potential O2 demand related to ozonation as an advanced treatment option for the same WWTP.

3. Results - Full replacement of the delivered LOX yields net margins of 84-168 k€/y, depending on O2 sale price, with payback periods between 5 and 11 years. The break-even price is estimated at 0.136 €/kg O2. As shown in Figure 1, NPV increases linearly with O2 sale price, reaching approximately 1.2 M€ at 0.25 €/kg O2. The corresponding LCOH reduction ranges from 0.04-0.08 €/kg H2 (corresponding to 0.8-3.6 % O2 off-take, assuming 8760 full-load hours per year), achieved without additional electricity consumption. In a comparative scenario, advanced treatment via ozonation for post-biological polishing - in line with the new Directive (EU) 2024/3019 - was evaluated assuming partial residual chemical oxygen demand (COD) removal. Using a representative ozone (O3) dose of 0.6 g O3/g COD and a 10 wt.% ozone yield in corona-discharge systems, the related O2 demand increases to ~7000 t O2/y - an order of magnitude above the previous case study. Under similar O2 pricing assumptions, this scale effect substantially improves the revenue potential and reduces payback to near-term ranges (1-2 years). However, additional drying and conditioning CAPEX, alongside the added electrical consumption, fall within the WWTP operation scope and are not included in the assessment.



4. Conclusions - Short-distance integration of electrolytic oxygen within the H2tALENT framework is demonstrated through the valorization of a water electrolysis co-product. A stable contract-based revenue stream can be estimated under realistic industrial pricing conditions. While pure-oxygen aeration case study provides moderate economic gains, mainly due to the anticipated low O2 demand, advanced applications such as ozonation illustrate the potential impact of an increased take-off scale, subject to added regulatory and operational constraints. The results highlight the importance of proximity and coordinated planning for unlocking cross-sectoral value within similar industrial clusters.

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6. Acknowledgements - The authors acknowledge the European Union through the Clean Hydrogen Partnership for funding H2tALENT (HORIZONJTI-CLEANH2-2023-06-02; Grant Agreement n. 101137611).

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The potential of nanofiltration and reverse osmosis for treatment and reuse of stormwater runoff from expressway runoff

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1. Introduction - Rainwater is increasingly recognized as an alternative water resource with the potential to reduce pressure on limited water resource problem. Studies on rainwater harvesting and treatment has primarily focused on its collection from different types of roof coverings surfaces [1,2,3]. In contrast, significantly less attention has been given to runoff from surfaces such as roads and parking areas. These sealed surfaces are typically equipped with retention basins designed to capture and store surface stormwater runoff. Therefore, the aim of this study is to evaluate the performance and efficiency of nanofiltration (NF) and reverse osmosis (RO) in treating stormwater runoff collected in retention basin. The novelty of this study lies in evaluating the possibility of reusing stormwater as an alternative water resource and in comparing the effectiveness of selected membrane technologies for its treatment.

2. Results and Discussion - In the filtration process carried out at constant pressure (RO: 4 MPa, NF: 1.5 MPa) and at the same 70% recovery rate, the NF process was characterized by a higher and more stable permeate flux than the RO. The removal efficiency of NF for monovalent and multivalent ions was in range 38-40% and 54-97%, respectively. The metals removal ranged from 27% (Cd) to 99% (Fe). RO almost completely removed from stormwater runoff salinity and ions (Cl^-: >99%, Na^+: > 99%, EC: 99%, TDS: 98%) and had over 80% removal efficiency for all analyzed metals. Both processes showed only moderate ΣPAH removal (NF 39.68%; RO 56.82%) and incomplete TOC rejection. The most realistic NF permeate end-use include: non-potable technical water for cleaning (floor washing, surface washing), industrial/utility uses tolerant to moderate salinity or as pretreatment step before RO filtration. The most practical applications for RO permeate are: domestic/non-potable water (flushing toilets, washing floors, cleaning, watering green spaces), technical applications requiring low TDS/EC value (water for devices sensitive to salt deposition).

3. Conclusions - The NF and RO process can be used to recover water from retention basins collecting stormwater runoff from expressway runoffs. Obtained permeate can be used primarily for non-potable reuse. RO permeate offers broader applicability due to very low mineralization. NF is better aligned with technical reuse where elevated Na^+/Cl^- are acceptable or as a pretreatment step before RO.

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100638.

Acknowledgments - The research was carried out as part of research work WZ/WB-IIŚ/3/2025 at the Bialystok University of Technology and financed from a subsidy provided by the Ministry of Education and Science. [pic] ABSTRACT BOOK

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Microwave-assisted synthesis of carbon nitride for enhanced pollutant degradation under simulated solar irradiation

degradation under simulated solar irradiation

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1. Introduction - The scalating presence of emerging pollutants in wastewater, notably the anti-epileptic drug carbamazepine (CBZ) and the endocrine disruptor bisphenol S (BPS), represents a significant threat to aquatic ecosystems due to their persistence and inherent toxicity [1]. Since conventional wastewater treatment plants are not designed to eliminate these recalcitrant compounds, the development of advanced oxidation processes has become imperative. Among these, heterogeneous photocatalysis using graphitic carbon nitride (g-C3N4) stands out as a non-metallic, chemically stable and low-cost material. In this context, microwave-assisted synthesis emerges as a rapid and sustainable strategy for optimising this semiconductor, enabling its textural and electronic properties to be modulated efficiently [2]. This study investigates the impact of key operating variables on the photocatalytic efficiency of g-C3N4 for the degradation and mineralization of CBZ and BPS under simulated solar irradiation. Furthermore, the reaction mechanisms were elucidated, and the catalyst's stability and reusability were evaluated.

2. Experimental - Photocatalysts were synthesized via microwave-assisted synthesis using 50% (w/w) urea/thiourea mixtures. The process was conducted in a Phoenix microwave oven at 500-550 °C for 3 h. The samples were characterized by X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD), Fourier-transform infrared (FT-IR) spectroscopy, N2 adsorption at -196 ºC and UV-vis diffuse reflectance spectroscopy. Photocatalytic activity was evaluated by degradation of 0.5 mg/L of CBZ or BPS using a Pico Solar Simulator 350-1100 nm with a catalyst loading of 0.75 g/L. Reactions were performed at 25 ºC and 500 rpm, and CBZ and BPS concentrations were determined by HPLC.

3. Results and Discussion - The CN1 catalyst exhibited the most favourable textural properties, featuring a specific surface area of 47 m^2/g, which was higher than those obtained with the other precursor mixtures. XRD analysis revealed that CN1 possessed the smallest crystallite size, resulting in a less condensed structure with a higher density of surface defects. Furthermore, XPS confirmed that CN1 has the lowest N1/N2 ratio (1.77), this indicates the presence of nitrogen vacancies that effectively inhibit charge recombination. Under these conditions. CN1 achieved 71.6% degradation of CBZ and 88.7% of BPS within 120 min. The optimal catalyst dose was 0.50 g/L, as higher concentrations caused light shielding effect. The material demonstrated high stability, maintaining BPS degradation rates above 80% after four consecutive cycles.

Table1. Physicochemical characterization

Sample	S_{BET} (M^2/G)	D_{002} (nm)	E_g (eV)	C/N
CN1	47	3.35	2.65	0.89
CN2	17	4.20	2.71	0.81
CN3	12	3.73	2.74	0.81

4. Conclusions - Microwave-assisted synthesis using urea and thiourea yields a highly efficient g-C3N4 photocatalyst for water remediation under solar irradiation. The presence of nitrogen defects and an optimised bandgap significantly enhance the removal of recalcitrant contaminants. This study establishes

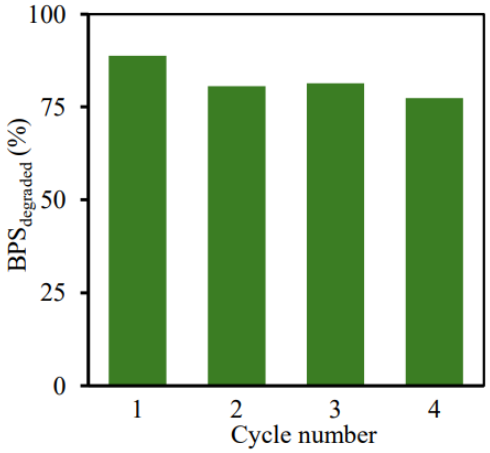

Figure 1. Degradation of BPS by CN1

this methodology as a sustainable, rapid and cost-effective technological alternative for wastewater treatment, ensuring economic viability through the excellent reusability and stability of the photocatalyst.

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Wastewater Treatment Plants as Hotspots for Antimicrobial Resistance Dissemination in Coastal Environments: Evidence in Gran Canaria (Spain)

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1. Introduction - Wastewater treatment plants (WWTPs) are recognized as key hotspots for the emergence and dissemination of antimicrobial resistance (AMR) in the environment. The continuous input of contaminants of emerging concern (including antibiotics), resistant bacteria, and antimicrobial resistance genes (ARGs) into treatment systems promotes their persistence and potential release into receiving ecosystems. This issue is particularly relevant in highly populated island regions such as Gran Canaria, where treated wastewater is extensively reused and discharged into coastal waters through submarine outfalls. This study aims to assess the occurrence and distribution of AMR and ARGs in WWTP effluents and adjacent coastal environments in Gran Canaria island (Spain).

2. Experimental - Water samples were collected from two WWTP effluents and corresponding impacted coastal areas. Sampling, transport, and storage were conducted under controlled conditions to preserve bacterial integrity. Microbiological characterization included the isolation and quantification of bacteria commonly used as fecal indicators (Enterococcus spp and Enterobacteriaceae), as well as other relevant genera (for example Pseudomonas), using membrane filtration and selective culture media. Representative isolates were subjected to antimicrobial susceptibility testing by disk diffusion method (antibiograms) to determine their phenotypic resistance profiles.

In parallel, genetic characterization was performed using high-throughput shotgun metagenomics, enabling comprehensive identification and quantification of ARGs and mobile genetic elements associated with horizontal gene transfer.

3. Results and Discussion - Preliminary results reveal the presence of resistant bacteria in WWTP effluents and nearby coastal waters included in our study. Phenotypic analyses indicate resistance to several antibiotic classes, suggesting selective pressure within treatment systems.

Metagenomic analysis confirms the widespread occurrence of ARGs, including genes associated with resistance to clinically relevant antibiotics, as well as mobile genetic elements that may facilitate their dissemination. The detection of these markers in coastal environments suggests connectivity between wastewater discharges and the spread of AMR beyond treatment facilities.

4. Conclusions - WWTP effluents can act as significant sources of antimicrobial resistance in coastal environments, particularly in water-scarce island regions. The combined presence of contaminants of emerging concern, resistant bacteria, ARGs, and mobile genetic elements suggests a high potential for environmental dissemination. These results underline the need for improved monitoring strategies and advanced treatment approaches to mitigate AMR spread and protect environmental and public health.

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Microbial Desalination Cell for Desalinated Water Production from Energy sector wastewater

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Abstract. Microbial desalination cell (MDC) technology arises from the integration of membrane-based technologies with bioelectrochemical systems (BES). These systems rely on the use of electrogenic bacteria capable of transferring electrons, generated during the oxidation of organic matter, to a conductive material, thereby converting chemical energy into electrical energy [1]. Through this capability, BES can recover energy from the organic matter present in wastewater, turning it into a renewable energy source. As a result, MDC systems can simultaneously treat wastewater, generate energy, and desalinate brackish or seawater without requiring an external power supply.

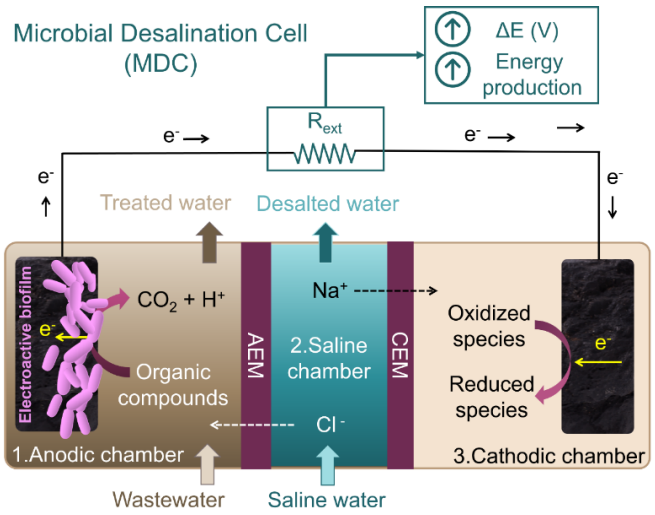

Figure 1. Schematic representation of a microbial desalination cell. AEM: anion-exchange membrane; CEM: cation-exchange membrane. From left to right: anodic compartment / central saline compartment / cathodic compartment.

A conventional MDC unit consists of three chambers (Fig. 1). When organic matter is fed into the anodic compartment, for instance in the form of wastewater, and the cathodic compartment is supplied with a catholyte containing dissolved oxygen, a potential difference is established between both electrodes. As a result, anions and cations from the central saline compartment migrate towards the adjacent compartments through their respective membranes in order to balance the charges within the system, thus achieving water desalination[2].

This communication presents a feasibility study on the production of desalinated water from wastewater generated in the oil & gas sector. The aim of this study is to evaluate the use of oil & gas industrial wastewater as the anodic feed in an MDC system to desalinate a saline stream and adapt its conductivity for potential reuse within the same industrial sector (electric conductivity below 1000 µS/cm), without external electrical energy input for the desalination process.

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Anaerobic digestion of poultry manure: biogas potential, process optimization and digestate valorization

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1. Introduction - The Moroccan poultry sector has experienced sustained growth, with national poultry meat production exceeding 782,000 tons, generating significant quantities of manure and litter whose management poses major environmental and economic challenges [1]. Anaerobic digestion offers a promising valorization pathway by simultaneously producing renewable biogas and nutrient-rich digestate that can be used as a biofertilizer [2]. However, the high nitrogen content of poultry manure may lead to ammonia inhibition and reduced process performance, requiring optimization strategies such as co-digestion, C/N ratio adjustment, pretreatments, and nitrogen recovery technologies.

Experimental evaluation of the biomethane potential of two poultry manure (PM) types was conducted. The manures were classified according to the predominant bedding material used by farmers: PM-SD corresponds to poultry manure from sawdust-based bedding systems, while PM-ST corresponds to poultry manure from straw-based bedding systems.

2. Experimental - Biomethane potential tests were conducted in triplicate using 500 mL glass reactors (400 mL working volume and 100 mL headspace) operated under mesophilic conditions (37°C) for 15 days. Biogas production was continuously monitored using an Automated Methane Potential Test System (AMPTS), while gas composition (CH_4, CO_2, and N_2) was analyzed by gas chromatography. The reactors were mechanically mixed at 40 rpm throughout the experiment.

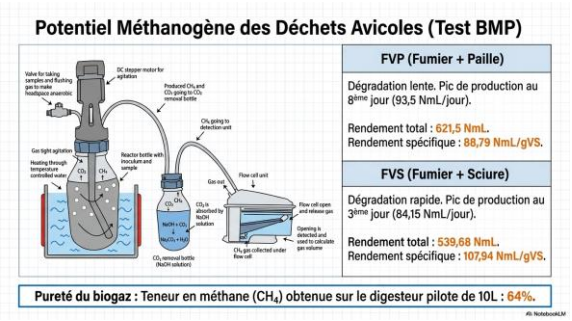

Image 1. Experimental setup

3. Results and Discussion - The results revealed significant differences in anaerobic digestion performance. PM-ST achieved a higher biogas yield (107.93 Nml/gVS) and methane content (67%) than PM-SD (88.79 Nml/gVS and 40% CH_4), likely due to its lower nitrogen content, which reduced ammonia inhibition during the digestion process.

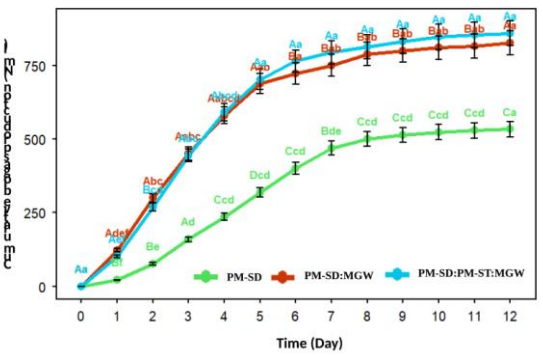

Image 2. Biogas production

To enhance process performance of PM-SD, co-digestion trials were conducted using municipal green waste (MGW). The mixture PM-ST:PM-SD:MGW (40:35:25) increased methane production by 47% within 13 days, compared to PM-SD mono-digestion. Methane concentrations reached up to 53% in co-digestion systems, highlighting the benefits of substrate complementarity for improving process stability and biogas production.

A thermo-alkaline pretreatment (70°C, pH 9 for 2 h) was also investigated; however, it promoted ammonium release and increased ammonia inhibition, resulting in a decline in biogas quality.

Digestate characterization revealed an enrichment in plant-available nutrients, particularly ammonium (NH4+) and assimilated phosphorus (P2O5), confirming its potential use as a biofertilizer.

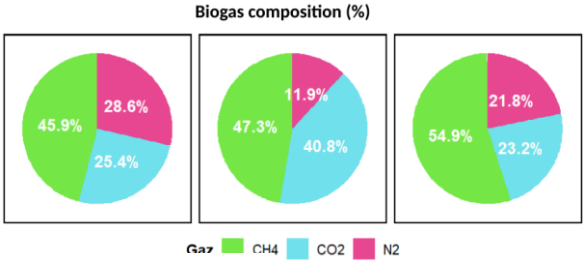

Image 3. Biogas composition

4. Conclusions - The study demonstrated that PM derived from straw-based bedding exhibited superior anaerobic digestion performance compared to sawdust-based manure, while co-digestion with municipal green waste increased methane production by up to 47%. The results also confirmed the potential of digestate as a biofertilizer and highlighted nitrogen recovery as a promising strategy to maximize resource recovery within a circular bioeconomy framework.

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Assessment of Contaminants of Emerging Concern in Insular Aquatic Environments: From Wastewater to Coastal Systems

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1. Introduction - The discharge of treated wastewater is a major pathway for the release of anthropogenic contaminants into marine ecosystems[1]. This issue is particularly relevant in densely populated insular regions such as Gran Canaria, where water scarcity drives intensive reuse practices and increases pressure on already overexploited aquifers [2]. In this context, monitoring contaminants of emerging concern (CECs) in wastewater treatment plant (WWTP) effluents and receiving coastal waters is essential not only to assess environmental impact, but also to support the development of regulatory frameworks and advanced treatment technologies for safe water reuse [3].
This study aims to assess the occurrence of a broad range of CECs in WWTP effluents and in coastal areas of Gran Canaria island (Spain), directly impacted by these discharges, contributing to a better understanding of land-sea contaminant transfer in water-scarce island environments.

2. Experimental - A target screening of more than 50 compounds with diverse physicochemical properties was carried out. Water samples were collected, transported under refrigerated conditions, filtered through 0.7 µm glass fiber filters, and stored prior to analysis. Sample preparation was based on solid-phase extraction (SPE) using complementary mixed-mode sorbents, namely strong cation-exchange (MCX) and weak anion-exchange (WAX), enabling the simultaneous extraction of compounds with different ionization properties.
Extracts were subsequently analyzed by ultra-high performance liquid chromatography coupled to tandem mass spectrometry (UHPLC-MS/MS). Detection was performed using multiple reaction monitoring (MRM) in both positive and negative electrospray ionization modes to ensure high sensitivity and selectivity across all target analytes.
3. Results and Discussion - Preliminary results reveal the widespread occurrence of CECs in the WWTP effluents and receiving coastal waters under study. A consistent chemical signature was observed across the studied treatment plants, indicating continuous inputs of anthropogenic contaminants into the marine environment.
The detection of these compounds in coastal samples suggests incomplete removal during wastewater treatment and highlights the direct influence of land-based sources on marine water quality. These findings underline the vulnerability of insular aquatic systems to diffuse chemical pollution.
4. Conclusions - This study provides a robust analytical approach for the determination of multi-class contaminants in complex aquatic matrices. The results highlight the need for continuous monitoring of CECs in island environments, particularly where water reuse is a key resource management strategy. The dataset obtained establishes a baseline for future environmental assessments and may support the optimization of wastewater treatment processes aimed at reducing contaminant release into coastal ecosystems.
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Sustainable and Energy-Efficient Wastewater Treatment Using TAYA Technology: Operational Dynamics, Advanced Nutrient Removal, and Multi-Year Performance

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1.Introduction- Decentralized and industrial wastewater treatment requires robust, energy-efficient technologies capable of meeting stringent effluent standards under variable climatic conditions. TAYA is a reciprocating, fixed-film system consisting of two interconnected basins filled with gravel or plastic media that support biofilm growth and are operated in alternating fill-and-drain cycles. These cycles generate temporally and spatially variable redox conditions. During the fill phase, rising water levels supply the biofilm with substrates, resulting in the sorption of organic matter and ammonia, while providing a fresh carbon source and creating anoxic conditions that drive denitrification. During the subsequent drain phase, the falling water level draws air into the bed, inducing passive aeration and unrestricted exposure of the biofilm to atmospheric oxygen. This enables organic matter oxidation and nitrification. Together, these alternating conditions achieve comprehensive organic and nitrogen removal within a single treatment stage without external carbon addition. To reduce operational costs, the system leverages gravity for the first 50% of the water transfer cycle. This gravity-driven approach, combined with the use of highly energy-efficient propeller pumps, allows the system to achieve up to 80% energy savings compared to conventional activated sludge processes. While the scientific basis remains identical across all applications, TAYA systems are highly adaptable in terms of footprint, media type, and cycle design to accommodate varying wastewater characteristics and required effluent qualities.

2. Experimental- Multi-year operational datasets were analyzed from three full-scale TAYA installations: two municipal systems (a desert region in southern Israel and a cold-temperate plant in Bennett, Colorado, USA) and one industrial facility treating mixed food-processing and sanitary wastewater. In the municipal sites, TAYA followed preliminary treatment and was designed for organic matter and nitrogen removal. The industrial system was implemented following anaerobic reactors pre-treatment and utilized a two-stage TAYA configuration: a primary plastic-media basin followed by a gravel-media basin for effluent polishing. In all cases, hydraulic configurations, cycle frequencies, and overall loading rates were tailored to local design constraints and effluent standards. Routine monitoring included COD, BOD, TSS, NH_4-N, TN, flow, temperature, and key operational parameters.

3. Results and Discussion- Across all evaluated sites, TAYA exhibited stable performance and high removal efficiency for organic matter and nitrogen. In the industrial application, the combined plastic and gravel media configuration successfully polished the anaerobically treated high-strength mixed wastewater. Despite ambient temperatures ranging from -19 to 43°C at the Bennett site and the high organic loads of the food industry, the systems consistently complied with regulatory limits. Specifically, average removal efficiencies across the municipal and industrial installations exceeded 90% for organic matter (COD, BOD) and ammonia (NH_4-N), and 83% for Total Nitrogen (TN). This resilience is supported by the fixed-film configuration; high-throughput microbial community analyses revealed high bacterial diversity and multiple functional groups that maintain ecological stability even under environmental stress. Furthermore, this configuration provides distinct operational advantages, including low net sludge production and significantly reduced operator intervention.

4. Conclusions- Full-scale data from contrasting climatic and industrial settings demonstrate that TAYA reliably achieves high removal of organic matter (>90%), ammonia (>90%), and total nitrogen (>83%) with up to 80% lower energy demand than conventional systems. These characteristics, along with system adaptability for complex streams like post-anaerobic food industry wastewater, support the application of TAYA as a robust solution with low operational costs and simple operation for diverse decentralized and industrial treatment needs.

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Catalytic membranes for ozone-driven water treatment made of environmentally compatible materials

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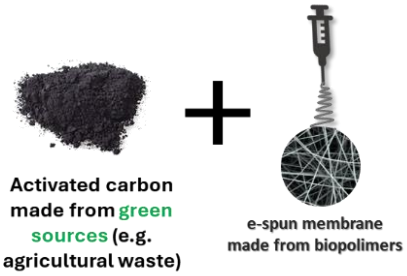
1. Introduction - Catalytic ozonation presents potential as a quaternary water treatment given its ability to remove organic pollutants that resist single ozonation, an advanced treatment process already implemented in water and wastewater treatment plants. Catalysts need to be active towards ozone (O3), and also easily separated and recovered from the treated water. Immobilizing powdered catalysts onto inert supports has been a strategy to facilitate such recovery and reuse of catalysts, but this usually leads to some loss of activity. Nanostructured supports, such as nanofibers, are ideal for this purpose because they provide an extensive surface area for catalytic reactions, potentially minimizing the activity loss, while allowing fluid passage, thus functioning as both catalysts and membranes. This work presents novel reactive membranes created for ozone-based water treatment, made entirely from environmentally compatible materials, aiming to combine waste recovery with water treatment.



2. Experimental - Activated carbons were used as environmentally compatible catalysts to incorporate into the catalytic membranes. These were made from biomass residues, namely coffee grounds and cork wastes (ACCG and ACCK, respectively), following the protocol already established in previous studies that optimizes their activity towards ozone [1, 2]. Commercial activated carbon (CAC) was also used for comparison. Electrospinning techniques were used to fabricate the nanofibrous supports. Polycaprolactone (PCL) was selected as the polymer to produce the nanofibers, given its biodegradability and biocompatibility. Preparation of polymeric solutions and electrospinning methodology can be found in [3]. To deposit a uniform catalyst layer on the membranes while preventing particle detachment, a suspension containing activated carbon powder and a binding agent was prepared to ensure homogeneous coating. This suspension was deposited on the membranes by vacuum filtration, and after drying at ambient temperature, a second layer of PCL nanofibers was deposited to confine the catalytic material between two PCL layers, resulting in a sandwich-like structure. This structure was then tested in a membrane flow-through reactor, where previously ozonated water crosses the membrane transversely. After passing through the membrane, the water stream recirculates back to the ozonation reactor, and this recirculation loop is maintained for 60 min. Samples were withdrawn at determined times to monitor the model-pollutant degradation. Oxalic acid (OXL) was selected as the model pollutant, given its known resistance to single ozonation [1, 2]. Therefore, any decrease in OXL concentration in the presence of O3 and the catalytic membrane can be attributed to catalytic O3 decomposition into more reactive species capable of degrading O3-resistant compounds.

3. Results and Discussion - Control experiments in the absence of O3 indicate that under the aforementioned experimental conditions, the catalytic membrane does not promote OXL removal by itself, indicating that adsorption onto the membrane was negligible. The degradation of OXL in the presence of O3 and the catalytic membranes with CAC was evaluated using one, two, and four stacked catalytic membranes. An increase in OXL removal from 46% to 48% was observed when increasing the number of stacked membranes from one to two; however, no further improvement was observed with additional increases in the number of membranes. Given the small difference, one single membrane was used for further experiments with catalytic membranes with ACCG and ACCK. Superior removals were attained with the latter, since it is known from previous studies that ACCK presents superior catalytic activity.

4. Conclusions - It is possible to conclude that catalytic membranes made entirely of environmentally compatible materials show catalytic activity towards ozone. Other environmentally compatible materials will be explored in future studies.

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Sustainable Graphene Oxide-like Membranes from Agar-Agar Waste for Arsenic Adsorption in Water Treatment

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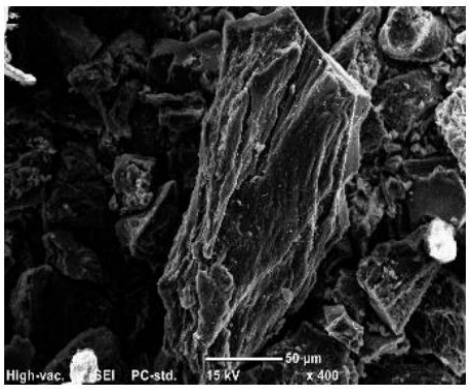
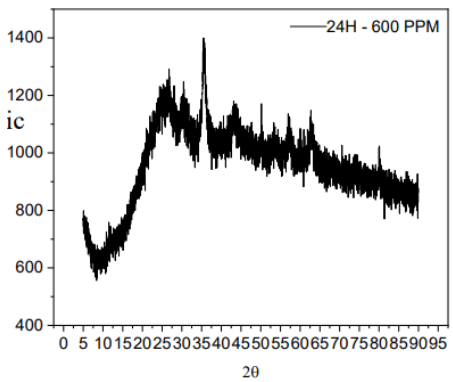
1. Introduction Arsenic (As) is a contaminant in groundwater, posing a significant threat to human health due to its high toxicity and potential carcinogenicity [1]. It is important to develop efficient technologies to remove As (III) from groundwater to ensure safe drinking water free of this metal. Graphene-based materials, especially graphene oxide (GO), have emerged as promising adsorbents due to their high surface area and rich surface chemistry [2]. However, the conventional chemical synthesis method of GO relies on graphite as a precursor, highlighting the need for more sustainable alternative sources. The objective of this work is to develop a graphene oxide-like material via chemical oxidation of biochar derived from the agar-agar industry, and to dope it with magnetite nanoparticles to evaluate its potential as a sustainable adsorbent for arsenic removal from contaminated waters. In **Figure 1,** we see a SEM micrograph showing a heterogeneous morphology with irregular aggregates and the absence of well-ordered layers, indicating partial exfoliation of the graphene oxide. This structure is consistent with the use of algal waste biomass as precursors for carbonaceous materials, whose amorphous nature favours the formation of limited graphitic domains and aggregation following Hummers-type oxidation. This morphology may be beneficial, as it increases the availability of active sites for the adsorption of species such as arsenic



2. Experimental - Graphene oxide-like material was prepared from an agar-agar industrial waste. The starting material is a solid residue generated after agar extraction from the macroalgae Gelidium corneum. This residue was subjected to pyrolysis at 750 °C for bio-oil and biogas production, yielding a carbonaceous biochar as the final solid product. In this work, the resulting biochar is used for the first time as a precursor for the synthesis of graphene oxide-like materials via chemical oxidation following a modified Hummers method [2], obtaining the material labelled as waste-GO. Membranes were developed using graphene oxide derived from seaweed waste and magnetite (Fe_3O_4) nanoparticles, synthesised by coprecipitation, with sonication used to homogenise the mixture. Arsenic retention efficiency was evaluated by ICP spectrometry, comparing the initial concentration of a standard solution with the concentration after it passed through the membrane.

3. Results and Discussion - X-ray diffraction (XRD) analysis 1400 24H - 600 PPM confirms the successful synthesis of the composite membrane consisting of graphene oxide functionalized with magnetite 1200 nanoparticles. The diffractogram shows a broad halo characteristic of amorphous carbonaceous materials, along with well- 1000 u.a. defined peaks assigned to the magnetite crystalline phase, with the most intense reflection at around 35° (2θ). The 800 amorphous structure of the synthesized carbonaceous material is attributed to the heterogeneous nature of the biomass precursor 600 and the partially disordered character of the graphene oxide, 400 consistent with this type of material.



4. Conclusions - This work highlights the sustainable synthesis of graphene oxide-like materials from agaragar

waste. The magnetite-doped composite shows promising arsenic adsorption efficiency, offering an alternative for water purification.

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Eco-friendly solution against plastics waste pollution: activated carbons for efficient adsorption of BPA in real aqueous matrices

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1. Introduction - Polyethylene terephthalate (PET) is among the most widely used plastics, commonly found in products such as food packages, drinks bottles and fibres [1]. PET recycling plays a critical role for achieving a circular economy and reducing its environmental impact. Recent research has shown great interest in the conversion of plastic waste into high-value carbon materials as a possible solution to the challenges posed by plastic recycling [2]. This is due to the high carbon content of plastics, which makes them excellent precursors for the synthesis of porous carbon materials, whose properties can be tailored using controlled processes. Bisphenol A (BPA) is a compound widely used in the fabrication of epoxy resins and polycarbonate plastics. It has been classified as an endocrine disruptor, and during recent years, high concentrations of BPA have been detected in surface water, groundwater and even tap water [3]. The most significant sources of BPA pollution include inadequately treated wastewater effluents, landfill leachate and the infiltration of BPA-containing industrial waste into the environment. Thus, this compound, as an endocrine disruptor, shows acute toxicity to aquatic organisms in both freshwater and marine environments at levels above 1000 mg/L, and can also pose a significant effect on human endocrine balance.

2. Experimental - In this case, an activated carbon was synthesized, using PET plastic waste as precursor, by chemical activation with KOH as activating agent (CAC), showing a well-developed micro-mesoporous structure, and high values of specific surface area as well as micro- and mesopores volume (SBET = 1349 $m^2\ g^{-1}$, Vmicro = 0.40 $cm^3 \cdot g^{-1}$, Vmeso = 0.96 $cm^3\ g^{-1}$). In order to obtain the equilibrium time and the equilibrium adsorption capacity for BPA, both adsorption kinetic and equilibrium isotherms were obtained in an orbital shaker at constant temperature (±30 ºC) and stirring (250 rpm), and using an adsorbent dose range of 0.012-2.5 g L^{-1}. In this case, three real aqueous matrices, e.g., surface water, a hospital wastewater and an industrial wastewater treatment plant effluent (WWTP) were used. Each effluent was spiked with an initial BPA concentration of 20 mg L^{-1} (the same that used in the studies with ultrapure water).

3. Results and Discussion - From the adsorption studies with the real effluents, it could be observed that the BPA adsorption capacity values dramatically decreased in the following order: 400 mg g-1 (ultrapure water, for comparison) > 250 mg g-1 (surface water) > 200 mg g-1 (hospital wastewater) > 100 mg g-1 (industrial WWTP effluent). This decreasing in the adsorption capacity can be mainly attributed to a competitive effect between the natural organic matter (NOM) present in the real matrices and the target compound, BPA, for the active sites of the activated carbon. In this sense, it could be observed that the decreasing in the BPA adsorption capacity was directly related to the TOC concentration of each effluent, macroscopic parameter which allows to elucidate the NOM content of a wastewater matrix: 8.7 mg L-1 (surface water) > 75.7 mg L-1 (hospital wastewater) > 258.3 mg L-1 (industrial WWTP effluent).

4. Conclusions - It could be concluded that all the three tested real matrices were efficiently treated by adsorption by using the synthesized CAC activated carbon. Additionally, a competitive effect between BPA and the NOM present in the effluents for the adsorbent active centers could be observed.

Acknowledgments. This work has been supported by the MCIN PID2023-150365OB-I00, funded by the MCIN/AEI/10.13039/501100011033, and the European Union Next Generation EU/PRTR programme. L. Rodríguez Arranz would like to thank the Ministry of Science, Innovation and Universities for awarding her pre-doctoral contract for doctoral thesis (PREP2023-001682).

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Impact of ATAD Sludge Treatment on Pollutant Load Recirculation in Biological Wastewater Treatment

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1. Introduction - Determining the method of sewage sludge processing and disposal is as important as selecting the wastewater treatment technology in which the sludge is generated. For both environmental and economic reasons, it is preferable to return treated sludge to the environment in the form of fertiliser. One of the methods for converting sewage sludge into usable biomass is Autothermal Thermophilic Aerobic Digestion (ATAD) [1]. The ATAD process reduces pathogen concentrations, stabilises organic matter, and prevents undesirable effects in soils following the application of treated sludge [2]. Implementation of this technology requires gravitational and mechanical thickening of excess sludge prior to stabilisation, as well as mechanical dewatering after the process. Leachates produced during thickening and dewatering, together with wastewater from off-gas treatment, are typically returned to the main wastewater stream and treated alongside raw sewage. The paper presents the results of studies on leachates generated in three facilities in north-eastern Poland employing the ATAD process, with particular emphasis on the balance of pollutant loads entering the biological stage of the wastewater treatment plant.

2. Results and Discussion - The results of the study are presented in Figure 1. During stabilisation, sludge undergoes partial mineralisation, with decomposition products transferred into the liquid phase. After dewatering, the leachate is recycled to the biological stage of the wastewater treatment process.

The organic matter content in the leachate depends largely on the proper operation of the dewatering process and, similarly, on sludge thickening prior to stabilisation. Reject water from ATAD constitutes a significant source of nitrogen, phosphorus, and organic matter returned to the biological stage. The main contributors are total Kjeldahl nitrogen (TKN) and total phosphorus (TP), which accounted on average for 22.4% and 31.8% of the influent raw wastewater load at the analysed treatment plants.

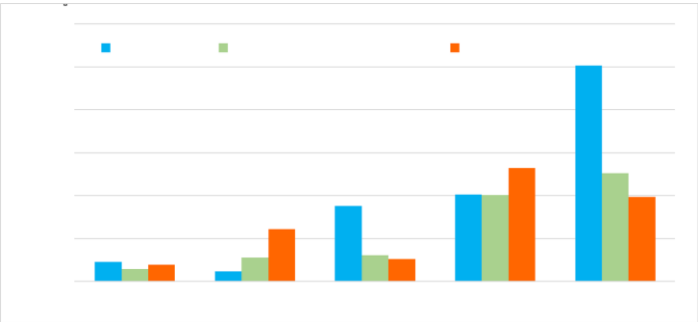

Fig 1. Share of leachate loads in the raw sewage loads, %

3. Conclusions - Rejected water from Autothermal Thermophilic Aerobic Digestion can be a significant source of nitrogen, phosphorus and organic matter returning to the biological treatment node from sludge treatment technology. In the case of modernisation of existing facilities where ATADs are used instead of simple sludge dewatering and hygienization methods, these loads can affect the efficiency.

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Acknowledgments - The research was carried out as part of research work WZ/WB-IIŚ/3/2025 at the Bialystok University of Technology and financed from a subsidy provided by the Ministry of Education and Science.

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Treatment of Antibiotic Mixtures by Electro-Fenton Process: Degradation of Sulfamethoxazole and Trimethoprim

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1. Introduction.

The presence of pharmaceuticals in waterways has heightened concerns about their effects on human and animal health. Although water treatment has been under development, the practical application of advanced processes, such as electrochemical oxidation, has been under investigation1,2. In this context, the present study aims to evaluate a 3D-printed reactor with double-gas-diffusion electrodes (GDE) for the in situ electrogeneration of H2O2 and the removal of pharmaceuticals by electro-Fenton (EF).

2. Experimental.

Sulfamethoxazole (SMX, C10H11N3O3S, CAS 723-46-6, ≥ 98.0%) and trimethoprim (C14H18N4O3, CAS 738-70-5, TMP, ≥ 98.0%) were purchased from Sigma Aldrich and applied to standard solutions, as well as on the preparation of synthetic solutions for all experiments. Vulcan XC-72 was used for GDE preparation by hot pressing in carbon fabric. A double GDE 3-D reactor was applied for the flow-through treatment process. High-performance Liquid Chromatography (HPLC) and total organic carbon (TOC) were applied for process monitoring.

3. Results and Discussion.

In this study, the degradation of SMX and trimethoprim TMP, commonly detected antibiotics in wastewater, was evaluated using an EF process operated at a current density of 4.0 mA cm^{-2}. The treatment performance was compared with that of anodic oxidation (AO) under similar operating conditions. The initial total organic carbon (TOC) concentration of the synthetic pharmaceutical matrix was 2776.2 ± 257.6 mg L^{-1}. The EF process demonstrated high removal efficiencies for both target compounds after 240 min of treatment, reaching 94.1% for SMX and 99.5% for TMP. In comparison, AO achieved 99.5% and 100% removal for SMX and TMP, respectively. However, EF exhibited substantially greater mineralization capacity, achieving 81.5% TOC removal, whereas AO achieved only 52.0% TOC reduction. These findings indicate that although both technologies were effective in degrading the parent compound, the EF process promoted more extensive oxidation of organic intermediates. The enhanced mineralization observed during EF treatment was associated with in situ electrogeneration of hydrogen peroxide (0.523 g L^{-1}) and the production of hydroxyl radicals through Fenton reactions.

4. Conclusions.

Overall, the electro-Fenton process proved to be an effective and environmentally relevant strategy for treating pharmaceutical mixtures containing SMX and TMP, particularly due to its superior mineralization performance compared with anodic oxidation alone. The results highlight the potential of EF systems for advanced wastewater treatment to remove persistent pharmaceutical contaminants.

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Mixotrophic Cultivation of Scenedesmus sp. and Chlorella sp. in hydroponic wastewater for Enhanced Nutrient Removal, Biomass Production and Lipid Accumulation

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1. Introduction. Nowadays, soilless farming techniques such as hydroponics have gained notable interest worldwide because of their ability to produce high - quality crops in controlled environments. In a hydroponic system, nutrient concentrations often exceed plant requirement limits, resulting in nutrient - rich effluents even after plant growth and if improperly disposed can pose a risk to environment.. An alternative solution for hydroponic WW treatment would be a microalgal cultivation systems, which can effectively assimilate nutrient such as nitrogen and phosphorus from hydroponic effluents, thereby reducing pollution. Hydroponic WW can be used as low-cost media for microalgal growth because they contain both macro and micro - nutrients. However, hydroponic WW contains low concentrations of organic matter (carbon) as an available carbon source, hence its potential as growth medium can be improved for further mixotrophic cultivation by supplementation with organic waste, such as whey. Therefore, mixotrophic cultivation of certain microalgae in the optimized media can potentially improve nutrient removal and lipid content in the microalgal biomass.

2. Experimental. The aim of this study was to investigate the effect of organic substrate supplementation to hydroponic WW and its contribution to nutrient uptake and lipid accumulation in Chlorella vulgaris CCAP 211/11 and Scenedesmus quadricauda CCAP 276/16 biomass. Selected microalgal cultures were cultivated for 14 days at 25°C in tomato hydroponic effluents supplemented with glucose (5 g/L) and cheese whey (10 %).

3. Results and Discussion. The results indicate that substrate composition strongly affected microalgal productivity and results varied between selected cultures. For C. vulgaris the highest biomass concentration was obtained in glucose - supplemented hydroponic WW, reaching 1.70 ± 0.01 g/L biomass, which was 3.6 times higher than in the control group. Lipid content in this group reached 24.72 ± 0.90% of biomass, compared with 13.45 ± 2.78% in the control. In contrast, S. quadricauda showed the best performance in whey supplemented media, where the biomass reached 2.67 ± 0.17 g/L which is 5.4 times higher than in the control group and lipid content increased to 35 ± 1.05% of the biomass, whilst control group only estimated to 12.95 ± 2.66%. Nutrient analysis confirmed that both microalgal species were able to reduce nutrient concentrations, specifically nitrogen and phosphorus when supplemented with organic substances. The highest phosphorus and nitrogen removal ratio was observed for S. quadricauda in glucose and whey supplemented hydroponic WW reaching 94.54% and 89.83%, respectively.

4. Conclusion. The results indicate that Hydroponic WW can serve as a low - cost medium for microalgae, while supplementation with glucose or whey can significantly improve biomass and lipid production simultaneously increasing the nutrient uptake ratios for both species.

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Institutional Acceptance of Water Reuse in Germany: Evidence from a Cross-Sectional Survey of Water-Sector Stakeholders

Institutional Acceptance of Water Reuse in Germany:

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1. Introduction – Climate change, recurrent droughts and hydrological variability increasingly challenge the traditionally water-rich image of Germany and raise questions about the role of unconventional water resources in future water management. At the European level, Regulation (EU) 2020/741 on minimum requirements for water reuse sets common water-quality classes, monitoring and risk-management obligations for the use of treated urban wastewater in agricultural irrigation and has applied in all Member States since June 2023. In Germany, implementation remains selective and contested, with debates over legal clarification, trace substances, groundwater protection, costs and administrative responsibilities [2-3]. While most previous research has focused on public and end-user acceptance, much less is known about the views of institutional stakeholders, even though their decisions are central to permitting, planning and implementing reuse projects.

2. Institutional Acceptance Survey – To explore institutional perspectives, a cross-sectional online survey was conducted between August and November 2021 among organisations and professionals in the German water sector, including environmental authorities, water suppliers, research institutions, NGOs and advocacy groups. The questionnaire contained 79 items grouped into five sections covering descriptive characteristics, acceptance and risk management, fiscal policy, sector performance and general opinion, and responses were mostly recorded on 10-point scales. A total of 53 completed responses were obtained from an initial contact pool of 720 institutions, yielding a response rate of about 7.4 percent; respondents were highly experienced (on average 22.9 years in the sector) and predominantly from research institutions, water authorities and water supply companies. Acceptance was measured for five reuse applications—food and agricultural products, swimming pools, non-potable household uses, landscape irrigation and recreational uses excluding swimming pools—alongside explanatory variables on scarcity perceptions, institutional trust, perceived barriers and arguments for and against reuse.

3. Results and Discussion - In 2021, intentional water reuse in Germany was still rare and poorly known, with nearly 70 percent of surveyed water-sector stakeholders reporting no prior knowledge and treated wastewater almost never cited as a primary or secondary source in agriculture or industry. Acceptance showed a clear hierarchy, with higher support for landscape irrigation, moderate support for non-potable household and recreational uses and low support for food-related and swimming-pool applications. Regression results indicated that perceived scarcity increases acceptance for several non-potable uses, that seeing Germany as water-rich lowers acceptance in food-related uses and that strong “arguments against” (health, contamination, costs, legal gaps, public opposition) significantly reduce acceptance in sensitive applications [1].

4. Conclusions - The survey offers an exploratory baseline of institutional acceptance of water reuse in Germany before Regulation (EU) 2020/741 became applicable and before detailed national rules and guidance existed. Acceptance is clearly use-specific and mainly shaped by fit-for-purpose logic, scarcity awareness and perceived health, contamination and legal risks, suggesting that policy should focus on applications with higher institutional support and back them with clear, credible quality and risk-management rules.

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Feasibility Study on the Microbial Degradation of Poly- and Perfluoroalkyl Substances (PFAS)

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1. Introduction. Poly- and perfluoroalkyl substances (PFAS) are a group of synthetic fluorinated compounds widely used in industry and consumer products. However, growing concerns have emerged regarding their persistence, bioaccumulation, and toxicity, which are mainly related to the high stability of the carbon-fluorine bond. The aim of this study was to investigate the potential of bacterial strains isolated from the wastewater treatment plant of an industrial facility to survive in the presence of PFAS and to identify microorganisms with possible relevance for their transformation.

2. Results and Discussion. Bacterial isolates were obtained on minimal MSM medium supplemented with PFOA and screened for dehalogenase and lipase activity. The results of selective cultivation showed that the investigated industrial wastewater treatment plant environment represented a suitable source of bacteria capable of surviving and growing under selective conditions supplemented with PFOA. Enzymatic screening successfully identified isolates with the highest enzymatic activity, which were taxonomically identified by 16S rRNA sequencing as Ochrobactrum tritici, Bacillus pumilus, Brucella anthropi, and Sphingobacterium siyangense. In parallel, Nanopore metagenomic sequencing was used to characterize the original microbial communities. Several bacterial genera with relevant enzymatic activity were identified, while metagenomics revealed differences in community composition among samples. Comparison of selective cultivation and metagenomic analysis revealed only minimal overlap between the two approaches. This discrepancy is expected, as selective cultivation enriches only microorganisms capable of growing under the applied laboratory conditions, whereas metagenomics captures the total DNA present in the sample regardless of culturability or physiological state. Additionally, cultivable taxa may occur at very low abundance and therefore remain undetected in metagenomic datasets, particularly when sequencing depth is limited. Taxonomic profiles obtained by metagenomics are also influenced by sequencing depth, DNA quality, bioinformatic workflows, and the accuracy of reference databases used for taxonomic assignment (1,2).

3. Conclusions. The results suggest that industrial wastewater environments may represent an important reservoir of microorganisms adapted to the presence of PFAS.

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5. Funding. This study was funded by SAS-NSTC-JRP-2024-06, SAS-NSTC-JRP-2027, APVV-23-0382, VEGA 2/0097/25

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Enhancing constructed wetland environmental sustainability and applicability to remote locations for wastewater treatment

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1. Introduction Constructed wetlands (CWs) are recognized as sustainable and low-cost wastewater treatment technologies. However, the extensive use of gravel as substrate contributes significantly to environmental impacts associated with extraction and transportation. The use of local soils combined with agricultural or forest residues could provide a more sustainable alternative. This study aimed to evaluate whether a silty-clayey soil could replace gravel as the main substrate in vertical-flow CWs (VFs) while maintaining satisfactory hydraulic and treatment performances.

2. Experimental - Ten 50-L VFs were operated under outdoor conditions at the University of Las Palmas de Gran Canaria (Spain). The systems included gravel-based controls and soil-based substrates combined with giant reed chips, palm mulch, or Cyperus fibers, with and without the presence of Cyperus alternifolius. Domestic wastewater from the university campus was treated under identical hydraulic loading conditions. Water quality was assessed through the analysis of BOD_5, COD, turbidity, total suspended solids (TSS), NH_4^+-N, PO_4^{3-}-P and E. coli. Spike experiments with steroid hormones and ftalates were also performed. The influence of substrate composition, vegetation and aging was investigated.

3. Results and Discussion - The soil-only VF experienced early clogging, confirming the hydraulic limitations of fine-textured soils. In contrast, the incorporation of plant residues and the presence of vegetation considerably reduced clogging and improved hydraulic functioning. High organic matter removal was achieved in all systems, with BOD_5 removals close to 90-95% and COD removals generally exceeding 60%. Planted soil-based VFs exhibited turbidity and TSS removals comparable to those of gravel VFs, reaching values above 85-90%. The presence of Cyperus alternifolius significantly enhanced ammonium removal, with efficiencies up to 90%, likely due to improved oxygen transfer and microbial activity in the rhizosphere. Phosphorus removal strongly depended on substrate composition, with palm mulch-soil VFs showing the best performance. Soil-based planted VFs also achieved similar E. coli reductions to those of gravel controls. Almost complete removal was obtained for steroid hormones and ftaltes in the spike experiments.

4. Conclusions The results demonstrate that silty-clay soils can be successfully used as substrates of VFs when combined with plant residues and vegetation. These amendments mitigate clogging risks and maintain treatment efficiencies comparable to conventional gravel-based VFs. The use of locally available soil and agricultural residues represents a promising strategy for reducing CWs' environmental footprint and economic costs, particularly in rural and remote areas where access to gravel can be limited. We acknowledge the Canarian Government for the WasteSpa project (ProID2024010016).

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Effluent Treatment by Magnetic Flocculation

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LEPABE - Laboratory for Process Engineering, Environment, Biotechnology and Energy, ALiCE-Associate Laboratory in Chemical Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal.

1. Introduction - Magnetic flocculation is a method that has been more intensively studied in the last decade as a potential alternative for the remediation of water effluents. The main problem presently is its unsuccessful application to real effluents (mainly wastewater) [1, 2]. To be able to clear a path for this practical application, studies still needed to be done, mainly concerning the influence of the type of effluent, and key parameters like the time needed for each step, wastewater content, reagents concentration, size of the particles, magnetic field characteristics, etc. This work aimed to evaluate the efficiency of a physicochemical treatment system based on magnetic flocculation for the removal of total suspended solids (TSS) in wastewater, and determining the effect of several key variables.

2. Experimental - A magnetic flocculation process was developed for the treatment of real wastewaters. The wastewater samples were supplied by an WWTP plant of Portugal (Porto region) and the WWTP of Salamanca. Three different points on the WWTP were considered for sample collection: entrance, exit of the first settling tank and exit of the biological reactor. Different magnetic particles in the range of 40-63 micron and in the range of 8-100 nm were used. Key variables such as dilution in water, polyacrylamide (PAM) concentration, the amount of magnetite, the type of magnet used, the presence or absence of magnetic field and magnetite and sedimentation times were varied and its effects determined.

3. Results and Discussion - Many results were obtained concerning the influence of the main variables and will be shown in the presentation. In Image I, an example is shown.

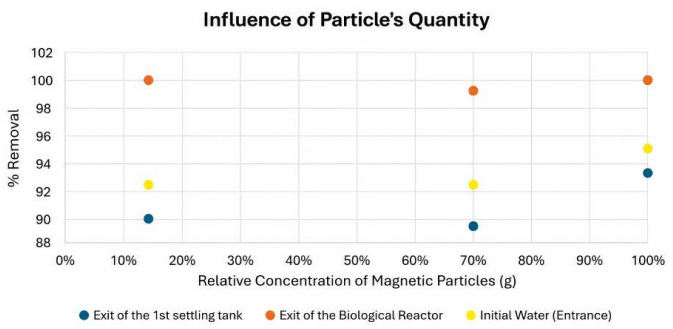

Image I. Influence of the Quantity of Magnetic particles in the Efficiency of the Remediation Process, per type of wastewater sample used.

4. Conclusions - The results demonstrate a high efficiency of the process, particularly when using magnetite and a magnet, achieving removal rates above 99% in wastewater with high pollutant loads. In addition, nearly instantaneous sedimentation times were achieved. Optimal PAM and magnetite dosages were identified, positioning this technology as a fast, effective, and adaptable solution for wastewater treatment.

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Advanced ZIF-8 Synthesis for Efficient Etoposide Adsorption and Pharmaceutical Wastewater Decontamination

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1.Introduction - The occurrence of pharmaceutical residues in aquatic environments represents an increasing environmental concern due to their persistence, biological activity, and potential toxic effects on ecosystems. Among these contaminants, anticancer drugs are particularly relevant because of their high pharmacological activity and the limitations of conventional wastewater treatment technologies for their complete removal. Etoposide, a widely used chemotherapeutic agent, may reach hospital effluents and wastewater streams, contributing to pharmaceutical pollution [1].

Metal-Organic Frameworks (MOFs, Figure 1) have emerged as promising materials due to their high surface area, tunable porosity, and versatile chemical functionality. In particular, Zeolitic Imidazolate Framework-8 (ZIF-8), composed of Zn^{2+} ions coordinated with 2-methylimidazolate ligands, has attracted attention because of its structural properties and potential interaction with pharmaceutical molecules [2].

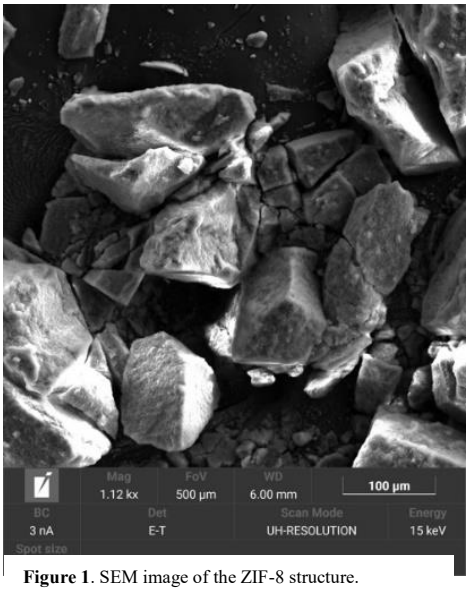

Figure 1. SEM image of the ZIF-8 structure.

2. Experimental - In this work, ZIF-8 was synthesized in methanol using zinc nitrate hexahydrate and 2-methylimidazole as precursors. After synthesis, purification, and drying, the obtained material was evaluated as an adsorbent for the removal of etoposide from phosphate-buffered saline (PBS) solutions. The adsorption process was monitored by High-Performance Liquid Chromatography (HPLC), measuring the decrease in etoposide concentration over time.

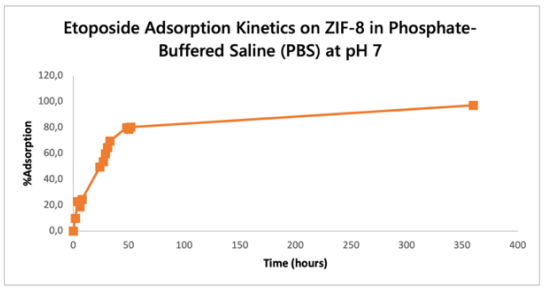

Figure 2. Adsorption Kinetics of Etoposide.

3. Results and Discussion - The synthesized ZIF-8 exhibited a remarkable affinity toward etoposide, achieving approximately 80% removal within the first 48 h (Figure 2), corresponding to an adsorption capacity of 8.5 mg g^{-1}. Complete removal of the pharmaceutical pollutant was achieved after 360 h, reaching a maximum adsorption capacity of 10.6 mg g^{-1} under the investigated conditions (21.258 mg L^{-1} etoposide, 100 mg ZIF-8, 50 mL solution). These results demonstrate the effectiveness of methanol-derived ZIF-8 for the sequestration of antineoplastic contaminants from aqueous media and highlight the potential of MOF-based adsorbents for advanced pharmaceutical wastewater treatment.

4. Conclusions - ZIF-8 represents a promising material for pharmaceutical wastewater decontamination, particularly for the removal of persistent anticancer drug residues. This study supports the development of

MOF-based adsorption strategies as advanced alternatives for improving water treatment processes and reducing the environmental impact of pharmaceutical pollutants.

5. References

[1] Patel, M. et al. Pharmaceuticals of Emerging Concern in Aquatic Systems: Chemistry, Occurrence, Effects, and Removal Methods. Chem. Rev. 2019, 119, 3510-3673.

[2] Ramos, V. C et al. ZIF-8 and Its Magnetic Functionalization as Vehicle for the Transport and Release of Ciprofloxacin. Pharmaceutics 2022, 14, 2546.

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Toward Smart Water Decontamination: Gold Nanoparticles for Etoposide Removal from Pharmaceutical-Contaminated Waters

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1.Introduction - The presence of pharmaceutical compounds in aquatic systems has become a growing concern in environmental research, particularly when these substances exhibit high biological activity and resistance to conventional treatment processes. Within this group, anticancer drugs deserve special attention because they are designed to interfere with essential cellular mechanisms. Etoposide, a commonly used chemotherapeutic agent, can be introduced into wastewater mainly through hospital and clinical effluents, making it a relevant target for water decontamination studies [1].

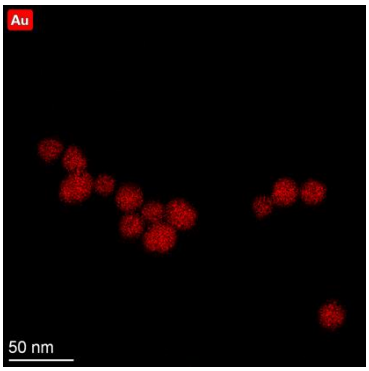

Figure 1. Gold nanoparticles.

Gold nanoparticles (AuNPs, Figure 1) have emerged as promising nanomaterials for water decontamination due to their high surface area, tunable surface chemistry, catalytic activity, and unique plasmonic properties. In particular, AuNP-based systems may enhance the adsorption or degradation of pharmaceutical molecules, especially when functionalized or coupled with photocatalytic supports, offering a potential strategy for the removal of etoposide from contaminated water [2].

2. Experimental - In this work, gold nanoparticles (AuNPs) were synthesized by citrate reduction using chloroauric acid and sodium citrate as precursors. The mixture was maintained at 90 °C under vigorous stirring until a colour change from pale yellow to light red confirmed the formation of AuNPs. AuNP-etoposide conjugates (AuNP-ETO) were then prepared by adding etoposide dissolved in methanol to the previously synthesized AuNP colloid and maintaining the mixture at 90 °C for 10 min.

The formation of AuNPs was monitored by UV-Vis spectroscopy through the characteristic surface plasmon resonance band around 520 nm. The crystalline structure was analysed by X-ray diffraction. Etoposide adsorption was evaluated after methanol washing and centrifugation by analysing the supernatants using UV-Vis spectroscopy and HPLC.

3. Results and Discussion - The synthesized AuNPs showed the characteristic optical response of gold nanoparticles, with an absorption band centred around 520 nm. After the preparation of AuNP-ETO and successive washing steps, no etoposide signal was observed in the methanol supernatants by UV-Vis spectroscopy or HPLC. These results suggest an effective interaction between etoposide and the AuNP surface, supporting the retention of the drug within the nanoparticle system.

4. Conclusions - Gold nanoparticles represent a promising platform for the interaction and potential removal of etoposide from contaminated media. The absence of detectable etoposide in the washing supernatants highlights the potential of AuNP-based systems for the development of advanced strategies in pharmaceutical wastewater decontamination.

5. References

[1] Patel, M. et al. Pharmaceuticals of Emerging Concern in Aquatic Systems: Chemistry, Occurrence, Effects, and Removal Methods. Chem. Rev. 2019, 119, 3510-3673.

[2] Tada, H. et al. Fundamentals and Applications of Gold Nanoparticle-Based Plasmonic Photocatalysts for Water Purification. ACS ES&T Engineering, 2024, 4(3), 506-524.

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Efficient Visible-Light-Driven Photocatalysis of Dimetridazole Using an Au/BiVO4/WO3 Ternary Heterostructure

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1. Introduction - The persistence of dimetridazole (DMZ) residues in aquatic environments represents a severe ecological concern, requiring advanced treatment methods such as heterogeneous photocatalysis [1]. However, single-phase semiconductors often suffer from poor quantum efficiency due to rapid electron-hole recombination. To overcome this limitation, constructing multi-interfacial ternary heterostructures has emerged as a powerful strategy to optimize charge separation and enhance degradation performance. The Au/$BiVO_4$/WO_3 system under UV-Vis light relies on a synergistic Z-scheme heterojunction and plasmonic effects to break down this nitroimidazole antibiotic. This process generates highly reactive oxidizing species ($HO\cdot$ and h^+) to mineralize the pollutant into water and carbon dioxide.

2. Experimental - All chemical reagents utilized in this study were of analytical grade and used as received. The BiVO4, WO3, and heterostructure BiVO4/WO3 samples (prepared at varying molar ratios of 1:1, 2:1, 1:2, and 4.5:1) were synthesized via a hydrothermal method. Subsequently, gold nanoparticles (AuNPs) were deposited onto the optimized samples at a load of 5 wt.% using the classic Turkevich method. The physicochemical, structural, and morphological properties of the materials were comprehensively evaluated using XRD, DRS, XPS and HRTEM. Additionally, electrochemical measurements were performed to investigate the charge-transfer dynamics. Photocatalytic evaluation was conducted in a specialized photoreactor equipped with a 15W low-pressure mercury. In a typical experiment, 0.1 g of the photocatalyst was dispersed in 100 mL of an aqueous DMZ solution (25 mg L−1) at a controlled temperature of 298 K. Aliquots were sampled at specific time intervals to monitor the reaction kinetics. The residual concentration of DMZ was quantified via High-Performance Liquid Chromatography (HPLC).

3. Results and Discussion - Characterization results revealed that the band gaps of WO3 and BiVO4 are 3.6 eV and 2.4 eV, respectively, indicating their potential to absorb a significant portion of visible light. XRD analysis of BiVO4 showed Miller indices corresponding to the monoclinic scheelite phase, with characteristic peaks at (121), (010), and (110). Meanwhile, WO3 exhibited peaks at (112), (020), and (122), attributed to its monoclinic phase. Across the different molar ratios, no peaks corresponding to impurities or secondary phases were detected, demonstrating the formation of a clean heterojunction. According to Figure 1, Au/BiVO4/WO3 composite (with 5% Au and a 4.5:1 molar ratio) achieved 97% degradation of DMZ within 120 min. In comparison, the BiVO4/WO3 heterojunction reached 44% degradation, while photolysis accounted for 70%. The lower degradation rate observed for BiVO4/WO3 is attributed to a shielding effect and rapid recombination.

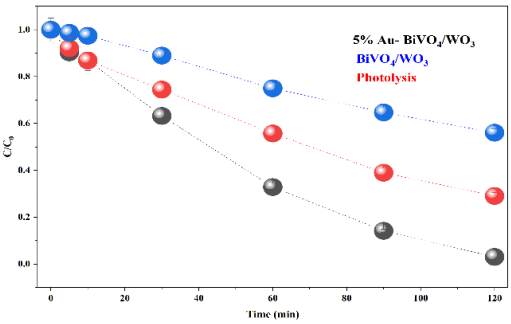

Figure 1. Degradation kinetics of DMZ. 4.5:1 $BiVO_4/WO_3$. $[DMZ]_0$=25 mg L^{-1}. T=298 K.

4. Conclusions - Au/$BiVO_4$/WO_3 ternary heterostructure is a viable alternative and low-cost material for removing antibiotics from wastewater. The physicochemical properties make it a novel material as a photocatalyst in the presence of UV radiation.

5. References

[1] Rivera-Utrilla, J., et al. "Removal of tetracyclines from water by adsorption/bioadsorption and advanced oxidation processes. A short review." Current Organic Chemistry 22.10 (2018): 1005-1021.