

CMTDE
2026

BOOK OF ABSTRACTS

10th Mediterranean Conference on Desalination and Water Treatment

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Le Sultan Hotel 4[★], Hammamet, Tunisia

Organized by



With the collaboration of



Water-Energy-Food-Ecosystems Nexus

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CMTDE 2026 OPENING KEYNOTE

Emeritus Professor Béchir HAMROUNI

Mr. Mondher Belaid, Minister of Higher Education and Scientific Research,
Mr. Hamadi HBAIEB, Minister of Agriculture, Water Resources and Fisheries,
Prof. Moez ECHAFRA, President of the University of Tunis El Manar,
Dear Guests, Dear Colleagues, Dear Participants,

It is my profound honor to welcome you to the 10th Mediterranean Conference on Desalination and Water Treatment (CMTDE 2026), convened under the theme "Water-Energy-Food-Ecosystems Nexus." Organized by the Tunisian Desalination Association (TDA) in collaboration with the University of Tunis El Manar (UTM), this conference brings together researchers, practitioners, and policymakers at a pivotal moment for global water sustainability. We gather in Hammamet from March 25 to 27, 2026, celebrating the 10th anniversary of this series.

The Mediterranean stands at the epicenter of the water crisis. According to the World Resources Institute, 15 of the 25 countries facing extremely high water stress are in MENA, and 83% of our region's population already faces severe water scarcity. Unconventional water resources—seawater desalination and treated wastewater—have therefore become indispensable for millions. Global desalination capacity has expanded remarkably. According to the latest IDRA Desalination & Reuse Handbook 2025–2026, produced by Global Water Intelligence (GWI), installed desalination capacity has grown by 40% since 2020. A comprehensive study published in *npj Clean Water* (January 2026) reports global contracted capacity of 128 million m³/day and operational capacity of 69.3 million m³/day. The MENA region accounts for 46.9% of global contracted capacity (60.1 million m³/day) and produces 50.68% of the world's brine (52.83 million m³/day). Meanwhile, the world generates 1.1 billion m³/day of municipal wastewater. Global water reuse capacity has surged by 52% since 2020, yet only 11–14% is beneficially reused. This is an extraordinary opportunity: Abu Dhabi already treats over 1 million m³/day of wastewater, with 80% reused and a target of 100% by end of 2026.

These solutions bring both promise and challenges. Modern reverse osmosis consumes only 4–6

kWh/m³, down from 14–28 kWh/m³ for thermal processes. In the Middle East, the average price of desalinated water for 2014–2024 stands at \$0.59/m³. Costs have fallen dramatically: from \$2.5–5 in the 1980s to under \$1 today, with some recent projects achieving \$0.4–0.5/m³. Yet energy still represents up to 75% of operating costs, and fossil fuel dependence persists. Wastewater reuse faces technical, regulatory, and social barriers—but offers unparalleled opportunities for circularity.

The scientific community is responding with renewables-powered desalination, next-generation membranes, hybrid systems, AI-driven monitoring, modular designs, and resource recovery from brines. In the Gulf, partnerships aim for megaton-scale CO₂ removal while recovering freshwater and transforming brine into valuable chemicals.

Research output in our field is growing rapidly, with China, the US, India, and Mediterranean partners leading in sustainable desalination, renewable integration, brine recovery, and reuse governance.

CMTDE 2026, building on nine successful editions, focuses on: sustainable desalination and reuse; membranes and emerging technologies; water-energy interconnections; environmental impacts and resilient systems; smart water solutions; and policy, governance, and finance for water-food security.

Over three days, we will hear from international experts through plenary lectures, oral presentations, poster sessions, and panel discussions. Selected papers will be considered for publication in special issue of “DesBooks” (Balaban desalination publication) or in “Euro-Mediterranean Journal of Environmental Integration” (Springer Journal).

I extend my deepest gratitude to the organizing and scientific committees, our sponsors, and each of you. Your engagement fuels forward-looking research, strengthens international cooperation, and catalyzes sustainable action.

Together, we can strengthen the resilience of our water systems. Together, we can build a water-secure future for the Mediterranean and beyond.

As we look out over this ancient sea, let us remember that it has connected civilizations for millennia. Today, it connects us—scientists, engineers, policymakers, and practitioners—in a shared mission: to ensure that future generations inherit a world where water scarcity is a challenge overcome, not a crisis endured.

Thank you for joining us at CMTDE 2026. I wish you a productive, inspiring, and transformative conference.

Professor Béchir HAMROUNI

President, Tunisian Desalination Association

Chair, CMTDE 2026

Hammamet, March 25, 2026

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Sami BEN REJEB



Dr. Ben Rejeb is an Energy Specialist with 19 years of experience in the oil & gas and energy transition sectors. He is an energy engineer with a PhD from North Carolina State University and also holds Bachelor and Master in law specializing in energy. Dr. Ben Rejeb has worked in Tunisia, the UAE, the USA, Algeria, Germany, and Mauritania. He has been based in Ministries of Energy in Africa in the last four years and is currently working with a Multilateral Development Bank.

Conference 1:

Navigating the complex interactions among water, food, and energy through Artificial Intelligence

Abstract

Disregarding our stance on Artificial Intelligence (AI), it will undeniably shape our near future. While advanced research has been performed on the integration of AI in the fields of food, energy, and water, it has considered these sectors separately. Few studies have tackled the intervention of AI on the entire nexus.

The aim of this presentation is to first provide the most up-to-date research in the field of AI as it relates to each of these sectors independently. Subsequently, the AI-driven nexus approach will be presented and discussed, for instance through the agent and agentic AI framework. Finally, specific suggestions will be provided within the local Tunisian, North African, and Mediterranean context for tackling relevant topics for research actors in this specific region.

Isabel OLLER ALBEROLA



Dr. Isabel Oller holds a PhD in Chemical Engineering from the University of Almeria (2008). She was awarded as “Extraordinary PhD award 2007-2008” by the University of Almería in the category of Experimental Sciences.

She is Head of the Solar Treatment of Water Research Unit at the Plataforma Solar de Almeria (CIEMAT). She is co-leader of the Research Group of Environmental Analysis from CIESOL (Joint Research Centre in Solar Energy between CIEMAT and the University of Almeria).

Dr. Isabel Oller has more than 25 years of experience in the field of industrial and urban wastewater treatment, disinfection and reuse by using advanced oxidation processes (with and without solar energy) and their combination with physic-chemical pre-treatments, advanced biological processes, membrane systems and other conventional technologies. She has developed this activity under her participation in more than 25 R+D European, national, regional and international Projects.

She has been awarded with the Royal Academy of Sciences Foundation Award for young female scientific talent in the category of Applications of Science to Technology (2024).

Isabel Oller is a recognized researcher included in Stanford University's annual list of the world's top 2% most influential scientists, a ranking based on citations, with her work highlighting her significant impact in fields like solar energy and water treatment. Her consistent inclusion in this prestigious Stanford ranking underscores her prominent global standing as a highly cited scientist.

Conference 2:

Water-Energy-Food nexus: Integration of solar and conventional technologies for urban wastewater recovery

*Oller, S. Malato, S. Nahim-Granados, I. Berruti, A. Ruiz-Delgado,
A. Hernández-Zanoletty, Plaza-Bolaños, A. Agüera*

Abstract

The reclamation and reuse of urban wastewater (UWW) for agricultural irrigation, especially arid and semi-arid regions, is currently gaining attention as a sustainable, stable and safe practice to address the water scarcity challenges. Within this perspective, urban wastewater treatment plants (UWWTPs) must implement those technologies that comply with the minimum quality requirements established in European Commission Regulation 2020/741 to guarantee the protection of the environment and human health before its reuse/discharge. On the other hand, the Directive 2024/3019 on UWW treatment introduces the mandatory to apply a quaternary treatment to UWWs eliminate the highest possible concentration of micropollutants (MPs). In this context, the UWWTPs must implement treatment technologies complying with a strict treatment validation program for both novel processes and upgraded current ones.

Integration of conventional and novel technologies must be integrated and combined to successfully recover urban wastewaters as alternative water source for different end users, such as crop irrigation, considering the high importance of sustainable agriculture in the countries of

Mediterranean Basin Area. In this talk, a complete analysis of the main parameters that must be evaluated in the combination of disinfection techniques (UVC, ozonation, etc.), with advanced technologies (giving special emphasis to those that can be assisted by solar radiation as renewable energy), for the simultaneous elimination of micropollutants and pathogens (including antibiotic resistance), for a safe reuse of treated urban wastewater will be presented. In addition, different case studies will be shown and analysed from the technical and economic points of view.

Alberto FIGOLI



Alberto FIGOLI is Director of the Institute on Membrane Technology – National Research Council of Italy (CNR-ITM), Rende (CS) Italy, since 1st March 2019.

He is President of the Territorial CNR Research Area of Cosenza, Italy, since 1st January 2021.

Winner of Global Prize for Innovation in Desalination 2023– Section “Beyond Water”, Jeddah (Saudi Arabia) 2023.

In May 1997, he started his PhD degree at Membrane Technology Group, Twente University (Enschede, NL), on Development of novel membranes for facilitated transport for the separation O₂/N₂, and he got the PhD degree in October 2001.

He graduated in Food Science and Technology at the University of Milan (Italy) in March 1996. He had a working experience at the Research Group of Quest International (Unilever) in Naarden (NL), May-December 1996.

He was researcher at CNR-ITM in Rende (CS, Italy) for the period December 2001- February 2019. He has been elected in the board of the European Membrane Society (EMS) and he was responsible for Awards and Summer school (2015-2017) and Secretary (2017-2019).

Winner of Global Prize for Innovation in Desalination 2024 Section “Beyond Water”, 2023.

He is involved in many international, European and national projects, as CNR-ITM scientific coordinator and/or participant. He has been invited speaker in several international Conferences, Seminars and Courses. He is reviewer of several International projects (ERC, National projects) and Research Agencies (as APN (France), NWO (Netherlands), FWO (Belgium), etc). He is author of more than 300 scientific papers and chapters published in international journals and 7 National/International patents on membrane technology. He is Co-Editor of 9 books and several special issues. Hindex (Scopus) 56.

Alberto Figoli is expert in the field of membrane technology, particularly in membrane preparation

and characterisation and application in environmental field and water treatment.

Conference 3:

Membrane Technologies for Chromium Removal from Natural Waters

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Rosanna De Rosa², Mattia Giagnorio³, Alessandra Criscuoli¹

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Abstract

To address the environmental issues of high chromium (Cr) concentrations into groundwaters, a multidisciplinary project was started with the aim to strategically integrate a hydrogeochemical survey, designed to delineate the spatial distribution of this specific contaminant species across ophiolitic aquifer cropping out in Lucania region (Southern Italy), with experimental evaluations employing membrane technologies like nanofiltration (NF) for laboratory and in situ water decontamination [1]. A systematic and spatially representative collection of groundwater samples was undertaken in the pilot area. The samples analyses showed a wide range of Cr concentrations. Samples showing the highest contaminant concentration ($30 \mu\text{g L}^{-1}$, and $40 \mu\text{g L}^{-1}$) were selected for subsequent membrane tests in the laboratory. Three commercial flat NF membranes supplied by Mann+Hummel group, not previously tested for their efficacy in the selective removal of chromium species from aqueous solutions, were chosen for laboratory trials: Trisep TS80 (polyamide), Trisep TS40 and XN45 (polypiperazine). The permeate fluxes and solute rejection of these membranes were systematically evaluated across a range of four transmembrane operative pressure: 3 bar, 6 bar, 9 bar, and 12 bar. The experimental data revealed that the Trisep XN45 membrane, as well as the other selected membranes, was able to lower Cr concentration below the law limit ($25 \mu\text{g L}^{-1}$). However, Trisep XN45 membrane type led to the highest permeate flux across all tested operative pressures, maintaining also a favorable residual ionic salinity of the treated permeate. Based on the achieved results, the Trisep XN45 membrane was selected for the realization of a membrane module, which will be installed on a solar-powered prototype to conduct tests in the pilot area for in-situ remediation applications.

Acknowledgements

The authors thank the project “Tech4You—Technologies for climate change adaptation and quality of life improvement”—National Recovery and Resilience Plan (NRRP), Mission 4,

Component 2, Investment 1.5, funded by the European Union–Next Generation EU, Identity code: ECS 00000009, CUP B83C22003980006.

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Vittorio BOFFA



Vittorio Boffa is Associate Professor of Inorganic Chemistry at the Department of Chemistry and Bioscience at Aalborg University in Denmark, where he has been based since 2010. Born in Italy, he earned his Master's degree cum laude in Industrial Chemistry from the University of Turin (Italy) and his PhD in Materials Science from the University of Twente (The Netherlands). His research focuses on the development of advanced materials for water purification, with a strong emphasis on functional membranes, (photo)catalysis, and integrated systems for wastewater treatment and resource recovery.

He has extensive experience in leading and participating in international research projects, including multiple EU-funded initiatives such as IN2AQUSA, NanoTheCABA, SusWater, and AQUALity. **Dr. Boffa** continues to bridge academic research and industrial innovation by patenting new technologies and contributing to the establishment of startups such as MagnaGlass, and Penso Green, thereby advancing global efforts in clean water provision and circular economy solutions.

Conference 4:

Metal-Organic Framework-based Functional Membranes for Water Desalination and Wastewater Treatment

*Vittorio Boffa**

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Abstract

Metal–Organic Framework (MOF) materials can revolutionize water desalination and wastewater treatment by combining tunable porosity and chemical functionalities. We developed strategies to fabricate MOF membranes with selectivities in the nanofiltration range and advanced

functionalities. MOF nanocrystals were combined with disordered matrixes to obtain continuous separation layers. NH₂-MIL-101(Al) and ZnO nanoparticles in a chitosan matrix demonstrated selective recovery of multivalent cations from seawater and brines [1]. Furthermore, we explore a novel charged MOF-glass composite material that actively sequesters Mg²⁺ ions through ion-exchange with its negatively charged matrix, enabling direct recovery of magnesium, an increasingly valuable resource [2]. Graphene-oxide membranes loaded with ZIF-8 nanosheets enhanced removal of organic micropollutants and heavy metals from urban and industrial wastewater, with improved structural adhesion and resistance to fouling [3]. We also combined ZIF-8@SiO₂-ZrO₂ core-shell particles on TiO₂ supports, yielding over 90% total organic carbon rejection and efficient pollutant abatement, while enhancing hydrophilicity, mechanical stability, and fouling resistance [4]. These examples highlight how designing structure and functionalities of MOF-based materials can elevate membrane performance in selectivity, permeability, and durability.

Keywords: Nanofiltration, Metal-Organic Frameworks, Functional Materials, Ion Selectivity, Water Depollution.

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- [4] X. Chen et. al. *ACS Applied Materials & Interfaces*, 2024, 16(9), 11835

Abdeltif AMRANE



Abdeltif AMRANE is a Professor – Exceptional class, UMR CNRS 6226 ISCR, University of Rennes / Member of the Algerian Academy of Science and Technology / Associate Researcher, INTI International University Nilai, Malaysia (2023-2025).

(Google Scholar: h-index: 73; citations: 21687 // Scopus: h-index: 62; citations: 16391).

1998: Thesis Director Enabling Degree (Univ. Rennes 1) / 1991: PhD in Chemistry (Univ. Rennes 1) / 1988: Master (DEA) in Chemistry (Univ. Rennes 1) / 1987: Chemical Engineering Degree (USTHB – Algeria).

Since approximately 20 years his research is entirely devoted to the development of combined

processes for the removal of organic pollutants in effluent wastewater and gaseous emissions within the CIP team.

He has managed 17 PhD theses as thesis director and 1 are in progress; he has also co-managed 26 PhD theses and 4 co-managements theses are in progress. He has been involved as a manager or a participant in several national and international projects, as well in international collaborations (Algeria, Belgium, Hungary, Iran, Lebanon, Mexico, Morocco, Poland, Portugal, Romania, Spain, Tunisia...).

He has published more than 600 international papers including 15 papers in press. He is the co-Editor of five books (Elsevier). He has also published 12 chapter books and has about 130 international and 20 national oral communications.

Conference 5:

Advanced Oxidation Processes for the treatment of recalcitrant organic pollutants in wastewater.

Abstract

The purpose of this presentation is to couple a biological treatment with a physicochemical pretreatment process for the treatment of aqueous effluents, either by Advanced Oxidation or by an Electrochemical Process. The pretreatment reduces the toxicity and improves the biodegradability of the effluent containing the persistent organic compounds to be treated; the biological treatment then completes the degradation of this effluent. Among the various Advanced Oxidation Processes (AOPs) considered, heterogeneous photocatalysis has been implemented in the UV and visible ranges and is currently being pursued through the implementation of new photocatalytic materials or its coupling with other processes, such as adsorption and the Fenton reaction, or its integration into a hybrid process involving a cold plasma. The generation of hydroxyl radicals involved in advanced oxidation processes (AOPs) can also be carried out electrochemically, a process that is relatively uncommon in combined processes. In this regard, electro-Fenton activity is being developed within the team, with significant advancements in heterogeneous electro-Fenton through the use of biocomposite materials as catalyst supports or through the development of novel electrode materials. Furthermore, when the target compound is electroactive, its oxidation or reduction can be implemented. Given the high reactivity and lack of selectivity of hydroxyl radicals produced by advanced oxidation, the main advantage of the electrochemical process should be its selectivity; a specificity that could be further improved by functionalizing the electrode surface. This latter aspect is being developed in close collaboration

with colleagues from the Condensed Matter and Electroactive Systems (MaCSE) team in our research unit.

Clara COMUZZI



Clara COMUZZI is a Researcher and Assistant Professor at the University of Udine, Italy, affiliated with the Department of Agricultural, Food, Environmental and Animal Sciences (DI4A). She can be reached at clara.comuzzi@uniud.it and is the author of approximately ninety publications in international peer-reviewed journals.

Since 2005, she has served as Principal Investigator at the University of Udine, where her research focuses on the structural characterization of biomacromolecules such as polysaccharides, the design and synthesis of new polymers from renewable resources, and the development of photo-active materials. She also works on functionalized porphyrins for photodynamic therapy and molecular probes, electroactive monomers for molecularly imprinted sensors, and innovative processes for mercury removal from sludge.

She earned her Laurea in Chemistry from the University of Padova in 1993 under Professor G. Scorrano, followed by doctoral studies at the University of Udine under Professor G. Dolcetti. Her international experience includes a visiting research position at Leiden University in the Netherlands with Professor J.H. van Boom from 2003 to 2004, and a post-doctoral fellowship at Florida State University in the United States with Professor G.R. Choppin from 1997 to 1999. Earlier in her career, from 1995 to 1997, she held an Assistant Professor position at the University of Udine working with Professor R. Portanova.

Her research interests encompass organic chemistry and biomaterials, thermodynamic and kinetic studies of metal complexes, NMR spectroscopy and structural characterization, sensor design for environmental applications, and water treatment for pollutants including mercury and emerging contaminants. She has contributed to numerous national and international research grants, including PRIN, FVG, CNR, INSTM, PoCN, and HeAD, and serves as a manuscript reviewer for major scientific journals published by ACS, Elsevier, RSC, and Taylor & Francis. Her teaching experience spans General Chemistry, Organic Chemistry, Advanced Spectroscopic Techniques, and Environmental Physical Chemistry. She is fluent in English, has reading knowledge of French, and is a native Italian speaker.

Conference 6:

Immobilized Photosensitizers in Polymeric Films for Light-Activated Antimicrobial Surfaces and Water-Related Applications

Abstract

Photodynamic inactivation (PDI) is a light-driven antimicrobial approach in which a photosensitizer generates reactive oxygen species capable of damaging microbial cells. In water-related contexts, PDI is being investigated as a complementary option to conventional disinfection, with interest in material configurations that enable reuse and reduce the need to handle dissolved active agents. This contribution considers polymer-based platforms embedding porphyrin photosensitizers within solid films, with emphasis on practical evaluation criteria relevant to aqueous environments. Key aspects include the influence of the polymer matrix on photosensitizer organization and interfacial properties, as well as operational features such as performance under controlled irradiation, behavior over repeated photodynamic cycles, and indications of material stability and component release. Results consistent with antimicrobial activity under visible-light exposure are discussed alongside observations on film integrity and regeneration/reuse concepts. In addition, the potential role of light-assisted antimicrobial surfaces in broader water-related scenarios is considered, including conditions compatible with low-energy light sources. Overall, the work frames how photosensitizer chemistry, polymer architecture, and irradiation conditions jointly shape both achievable antimicrobial outcomes and the constraints that must be addressed when considering photodynamic approaches in aqueous settings

ORAL AND POSTER PRESENTATIONS

CMTDE 2026_1

Optimizing irrigation practices in arid regions: the effectiveness of treated wastewater for sustainable agriculture

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Kasdi Merbah University of Ouargla, Algeria;

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Abstract

In Saharan areas, irrigation water requirements are high due to climatic conditions. It is essential to provide plants with sufficient water when they need it most to compensate for deficits during the growing season. Generally, the soil must be irrigated to maintain a moist bulb around the crop roots. To maximize the efficiency of water used by crops, it is therefore necessary to minimize losses due to runoff, infiltration, and evaporation. In this context, as a new technique, "drip irrigation" has been combined with one of the oldest methods used, based on the frequent pouring of water into porous pottery vessels buried in the soil, but replacing the latter with a plastic bottle that releases water through its perforated walls into the surrounding soil. On the other hand, a promising solution lies in the reuse of treated wastewater, which provides an alternative water source while addressing environmental concerns associated with wastewater disposal. And since the use of dune sands as a biological filter is an effective technique for wastewater treatment, we therefore opted to use the purified water from the Sidi Khouiled steppe of Ouargla and to fill the bottles with sand. The comparative analysis of the water needs estimated using the Cropwat software and the doses of water received determined experimentally reveals that the onion will require daily irrigation for 30mm and will receive 29mm during the initial phase, one hour thirty minutes (1h30), every two (2) days and will receive 31.25mm during the growth phase, one hour (1h), every two (2) days and will receive 70.75mm, during the mid-season phase and one hour every two days (2) the first decade, one hour and a half every five (5) days the second decade then only once in the last decade during the late season phase. The sand allowed a reduction of 37% in BOD, 18% in COD, and 54% in suspended matter. -saison. Le sable a permis une réduction de 37 % de la DBO, de 18% de la DCO, et 54% des MES.

Keywords: Irrigation, Cropwat, humidity, bottle, purified water, sand, water requirements

Desalination: Machine Learning-Based Prediction of Water Hardness Removal Efficiency in Pretreatment Processes

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¹Laboratory of Recovery and Recycling of Matter for Sustainable Development, USTHB, University of Science and Technology Houari Boumediene, Bab Ezzouar, Algiers, Algeria

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Abstract

Intelligent control of desalination systems offer new possibilities for optimizing membrane performance and ensuring sustainable operation. This work presents the development of a machine learning (ML) screening tool for predicting the removal efficiency of water hardness during the pretreatment stage of an industrial desalination process. The study focuses on the Palm Beach desalination facility, where pretreatment steps, including sand and cartridge filtration, were evaluated both before and after reverse osmosis. Key parameters such as pH, conductivity, salinity, total alkalinity (TAC), and total hardness (TH) were analyzed through laboratory-scale experiments. An artificial neural network (ANN) model was developed to simulate membrane-based desalination performance and predict water hardness removal under varying operating conditions.

Model validation using testing datasets demonstrated high predictive accuracy, with performance metrics of Mean Absolute Error (MAE = 0.0104), Root Mean Square Error (RMSE = 0.028), prediction average = 0.742, and coefficient of determination ($R^2 = 0.991$). The results confirm that integrating ML automation into desalination pretreatment enables enhanced process design, prevention of membrane fouling, optimization of permeate flux, and reduction of treatment costs.

Keywords: Desalination; Machine Learning; Pretreatment Automation; Water Hardness; Membrane Performance

Evaluating reuse of cement kiln dust as coagulant for wastewater treatment

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Abstract

This study was conducted to examine cement kiln dust (CKD) efficiency for wastewater treatment. We analyzed the physicochemical characteristics of wastewater before and after treatment and then we determined its removal potential. The optimum factors of the treatment process were determined using a jar test technique. It was pH (8.5), dosage (1.75 g) and grain size (0.1 mm) with contact time of 30 min at 150 rpm. CKD pollutant removal efficiency reached 89.7, 92.6, 39, 79, 71.2, and 94.6% for BOD, COD, TDS, salinity, conductivity and turbidity, respectively, with an increase in the concentration of DO of 89%. On the other hand, removal percent of heavy metals achieved were 86.3, 92.2, 82.4, 94.2, 91.2, 65, and 69.1% for Pb, Cd, Zn, Fe, Co, Ni, and Cu, respectively. The methodology carried out in this study indicated that CKD can be used as a good environmental alternative coagulant for low to moderate wasted water.

Key words : Cement kiln dust, Coagulant, Wastewater treatment, physicochemical, Heavy metals, Environmental alternatives.

Harnessing the WEF E Nexus with Nature-Based Solutions for Climate-Resilient Resource Management in Algeria and the Mediterranean

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Abstract

The Mediterranean region, and Algeria in particular, faces mounting pressures on water, energy, food, and ecosystems due to climate change, population growth, and increasing resource demands. Addressing these challenges requires integrated, cross-sectoral approaches that capture the complex interdependencies between resources. The Water–Energy–Food–Ecosystems (WEFE) Nexus provides a systems framework to understand these linkages and identify multi-sector solutions, while Nature-Based Solutions (NBS) ecosystem-centered interventions addressing societal challenges offer opportunities to enhance resilience in water-scarce, energy-dependent, and climate-vulnerable landscapes. This review synthesizes recent conceptual and methodological advances in WEFE and WEF nexus thinking, evaluates climate change impacts on the nexus in Algeria and across the Mediterranean basin, and examines evidence on the design, implementation, and limitations of NBS in arid and semi-arid contexts. The paper further surveys regional programs and projects, with a particular focus on the Partnership for Research and Innovation in the Mediterranean Area (PRIMA), that integrate WEFE and NBS strategies. Finally, it outlines actionable policy, technical, and research recommendations to accelerate the adoption of integrated WEFE–NBS approaches for climate-resilient resource management in Algeria and neighboring Mediterranean countries.

Keywords: WEFE Nexus; Nature-Based Solutions (NBS); Climate resilience; Arid and semi-arid regions; Climate change

Topographic and porous structure evaluation of halloysite for pefloxacin adsorption

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Abstract

This study delves into the topographic and structural characterization of Halloysite Nanotubes (HNTs) for the adsorption of Pefloxacin from aqueous media, integrating a statistical physics framework. Four adsorption models were tested, with the dual-energy bilayer model showing the best fit based on multiple error metrics (R^2 , Chi-Square, RSS, R^2_{adj}). The witnessed shift indicates that as temperature increases (FIG 1), Pefloxacin entities require higher activation energy to bind to the available area. This phenomenon can be ascribed to the enhanced thermal motion of free molecules at higher temperatures necessitating the overcoming of larger energy barriers for interaction with linking cavities [1]. At the molecular level, this could also signify the activation of more energetic docking pores or a more selective retention process favoring sites with stronger binding energies. The observed adhesion energies ranging from 15000 to 1050 J/mol fall within the upper range of typical physisorption energies. This suggests that the retention process on the HNTs area is primarily driven by physical adsorption mechanisms. Physisorption, characterized by Van der Waals forces typically involves retention energies between 2 and 40 kJ/mol. These interactions are generally weak and non-specific allowing for reversible adsorption. . Witnessed pores range from 0.2 μm to 2 μm , they fall into the category of mesopores to macropores (FIG 2) [2]. More importantly, the PSD inspection reveals a bimodal distribution of pore radii within the range of [0.5 μm to 2 μm] with each temperature showing two distinct peaks. The primary peak (broader peak) represents the dominant pore size while the secondary (smaller peak) corresponds to less prevalent pores or structural features within the material. Notably, as the operating temperature increases, both peaks shift to smaller radii [3]. This temperature-induced shift suggests a thermal effect on the material's pore structure where higher temperatures facilitate structural reorganization or contraction of the material leading to a reduction in pore sizes. This phenomenon could be attributed to the thermal expansion or contraction of the material's framework which modifies the pore architecture [4].

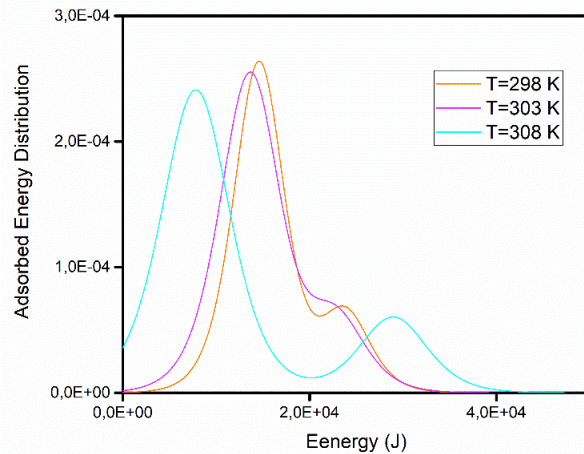


Figure 1: AED-energy relationship at three operating temperatures.

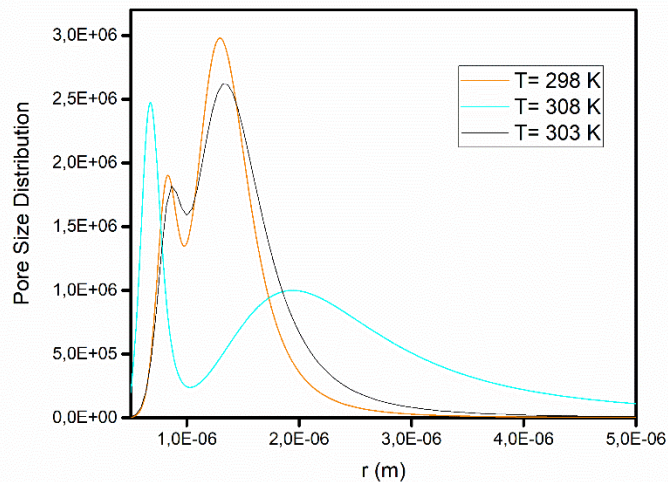


Figure 2: PSD-radius relationship at three operating temperatures

Keywords: Pefloxacin, Halloysite Nanotubes, Statistical Physics Approach AED, PSD.

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Decoding Van Der Waals forces in pefloxacin adsorption via energetic modeling on halloysite

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Abstract

This poster explores the role of van der Waals interactions in Pefloxacin adsorption onto Halloysite Nanotubes (HNTs), using an energetic modeling approach rooted in statistical physics. By comparing several adsorption models, the dual-energy bilayer model emerged as the most accurate. Energetic analysis (via AED) confirms the dominance of weak, physical van der Waals forces (< 25 kJ/mol). The plot (FIG1) presents the estimated linking energies which were found to be less than 24 kJ/mol. These low retention energies suggest that the extraction of Pefloxacin using HNTs from aqueous solutions is primarily a physisorption process [1,2]. The positive values of these energies align with the experimental observation of an endothermic reaction. More specifically, this low adhesion energy proves that no significant chemical bonds are being formed between Pefloxacin and the HNTs area. Instead, the docking phase is driven by weak and non-specific interactions since it falls within the range typically associated with Van der Waals forces. These forces do not involve electron sharing or transfer which is characteristic of chemisorption (80-400 kJ/mol). More importantly, in physisorption, the adsorbate molecules such as Pefloxacin, are more likely to remain mobile on the surface of the adsorbent. This mobility allows the free entities to reorient themselves or even migrate across the area leading to multiple potential linking configurations. The predominance of physisorption in this system implies that the anchoring process is likely to be rapid as physisorption typically occurs quickly due to the absence of an activation energy barrier [3,4]. Figure 2 details a proposed mechanism for Pefloxacin adhesion onto Halloysite Nanotubes.

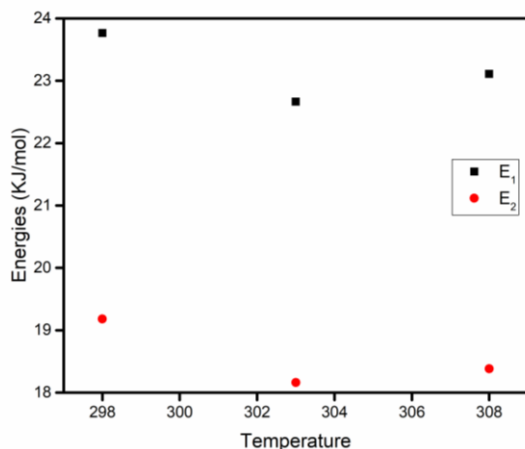


Figure 1: Changes of adhesion energies versus the temperature.

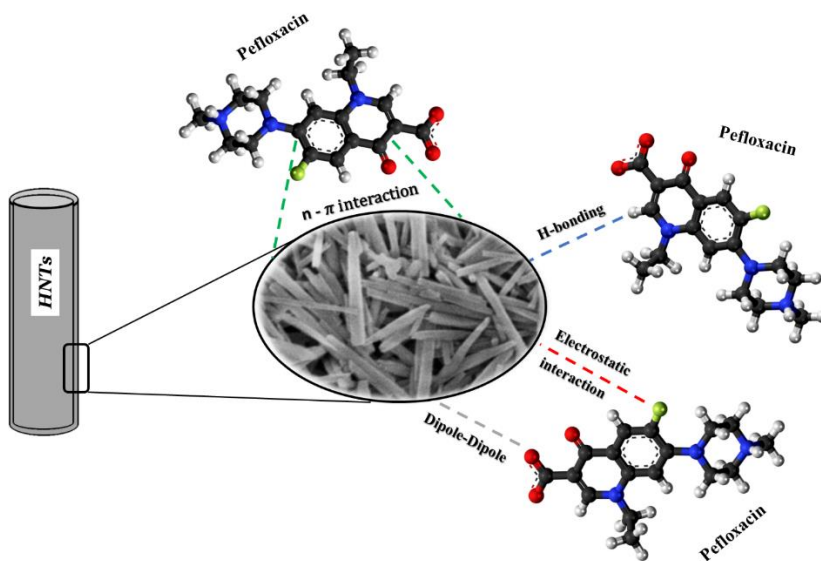


Figure 2: Mechanism for retention of Pefloxacin onto the HNTs.

Keywords: Pefloxacin, Halloysite Nanotubes, Statistical Physics Approach, energetic investigation.

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Evaluation of Physicochemical and Bacteriological parameters of Adardar spring water during two tamplng campaigns in Tizi Ouzou, Algeria

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Abstract

Water is an essential natural resource that sustains life on Earth and plays a key role in numerous environmental processes. The present study evaluates the drinking water quality of the Adardar spring, located in the municipality of Bouzeguene, in the Tizi-Ouzou region (Algeria). The assessment is based on two sampling campaigns conducted during the winter and summer of 2023, in accordance with the Algerian standards for drinking water quality.

Physicochemical analyses were performed after allowing the spring water to flow for at least one minute, followed by complete filling of 1,000 mL glass bottles. For bacteriological analyses, sterilized 500 mL glass bottles were filled to three-quarters of their capacity.

The results show that the water is moderately mineralized, with electrical conductivity values ranging between 256 and 261 $\mu\text{S}/\text{cm}$, remaining within the limits set by Algerian regulations for drinking water. Concerning organic pollution indicators, low levels of organic matter were recorded (0.08–0.4 mg/L), with no evidence of ammoniacal or nitrate contamination. Bacteriological analyses indicated the absence of thermotolerant coliforms and fecal streptococci. However, total coliforms were detected, with counts of 11 CFU/100 mL in summer and 212 CFU/100 mL in winter, exceeding the regulatory limit of zero.

Overall, the results suggest that the analyzed spring water is suitable for human consumption and does not present a significant risk to public health.

Keywords: Adardar spring; water quality, Sampling, Physicochemical and bacteriological parameters, Tizi-Ouzou.

Diversity of biochemical fruit quality traits in apple fruits during cold storage

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Abstract

Apple is a climacteric fruit and the cold storage is used to extend the shelf life of the product. After cold storage period fruit can present lack of organoleptic quality and chilling injury symptoms. The main objective of this study was to evaluate the pomological, biochemical and chilling injury symptoms in the apple cv. Golden during cold storage. For all agronomical and biochemical analyses, a representative fruit sample (20 fruits) was taken from private orchards located in the regions of Sbiba and Jedliene -Kasserine over the growing season (2024). Agronomical attributes such as fruit weight, firmness, soluble solids content (SSC), pH, titratable acidity (TA) and color parameters were recorded. Phenolic compounds, antioxidant activity and chilling injury symptoms were also evaluated. Results showed that major physicochemical traits differed between cold storage periods. The overall juice SSC levels at harvest ranged from 10.0°Brix to 14.0 °Brix. The observed differences in juice SSC and acidity levels in the studied samples resulted in remarkable variability in fruit ripening ratios. The phenolic compounds and antioxidant activity decreased after cold storage. After three months of cold storage at 4°C fruits no showed chilling injury symptoms.

Keywords: Apple, cold storage, fruit quality, antioxidant activity, chilling injury

Application of biostimulants to improve the tolerance of *Mentha spicata* L. under deficit conditions

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Abstract

Plants live in constantly changing environments that are often unfavourable or stressful for growth and development. Drought is one of the primary factors limiting yields; it greatly affects production in arid and semi-arid areas. In this context, we aimed to investigate the impact of the exogenous application of a phytohormone, salicylic acid (SA), and a fertilizer, boric acid (BA), on the physiological and photochemical responses of mint plants subjected to water stress simulated by 25% PEG-6000. To this end, three-month-old plants were divided into four blocks and irrigated with 50 mL of solution according to the treatment: distilled water (Block 1); PEG-6000 (Block 2); a mixture of PEG + SA (6 mM) (Block 3); and a mixture of PEG-6000 + BA (3 mM) (Block 4); stressed plants were compared with control plants. The obtained results revealed that water deficit affects all physiological and metabolic functions of mint plants, leading to a reduction in leaf water status, aerial growth, and fresh and dry leaf biomass, along with a marked decrease in photosynthetic pigments. Nevertheless, the application of biostimulants under stress conditions reduced the deleterious effects induced by PEG-6000. These positive effects were observed in plant growth, photosynthetic pigments, higher relative water content (RWC), and total antioxidant capacity, along with a strong accumulation of phenolic compounds and condensed tannins. This study clearly demonstrates the importance of salicylic acid (SA) and boric acid (BA) application in enhancing water stress tolerance and opens new perspectives for the use of these biostimulants in mitigating the negative effects of water deficit on plant production. Biostimulants in agriculture represent a promising approach for a more sustainable future. However, their success depends on proper application and the use of high-quality data.

Keywords: Water stress, PEG-600, phytohormone, micronutrient, resistance.

Mapping erosion using MLP: Integration of the LS factor and multi-temporal NDVI (Oued Isser, Algeria)

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Abstract

Water erosion represents a major threat to mediterranean watersheds. This study proposes an innovative approach based on artificial intelligence to map erosion susceptibility in the Oued Isser watershed (Algeria).

A multilayer perceptron (MLP) model was developed to classify erosion into five levels, integrating five parameters: the topographic factor LS, the digital terrain model (dem), and the NDVI vegetation index for three years 2020,2022,2024. This multi temporal approach captures the dynamics of vegetations cover. The performance results indicate very high model efficiency. achieving an overall accuracy of 99.83% on the validation dataset. Analysis of the confusion matrix shows a very clear separations between the different erosion classes, with an extremely limited number of misclassifications (152 cases). The least represented class, corresponding to areas of very high erosion (0.06% of pixels), is detected with perfect sensitivity (recall =100%), allowing for the identifications of all high -risk areas without omission. Furthermore, the evolution of the learning curves highlights a rapid convergence of the network, characterized by stable training process and the absence of overfitting. These results confirm the relevance of the pixel-by-pixel MLP approach for mapping areas makes this model a robust and directly usable tool for prioritizing soil conservation action. This study opens up promising prospects for the application of artificial intelligence in the environmental management of watershed.

Keywords: MLP, NDVI, LS, Oued Isser, water erosion

Performance and Cost Assessment of a Zeolite X–Polystyrene Ultrafiltration Membrane on Pyrophyllite Support

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Abstract

Membrane-based separation is a highly promising technique for water purification. While ceramic membranes offer excellent stability and antifouling properties, they are expensive. In contrast, polymer membranes are more affordable and easier to process. To combine the advantages of both, Mixed Matrix Membranes (MMMs) are developed by incorporating inorganic particles into polymer matrices. This enhances membrane strength, hydrophilicity and fouling resistance. This study aims to develop an ultrafiltration membrane by incorporating Zeolite X into a polystyrene (PS) matrix deposited on a pyrophyllite ceramic support. Zeolite X was synthesized and characterized using SEM, XRD, FTIR and Zeta potential analyses. Different amounts of the synthesized Zeolite-X (0-5 wt.%) was embedded on PS in order to enhance the structural properties of the membrane. The optimized membrane demonstrates a dye rejection of approximately 99% for DR80 with a permeability of 40 LMH/bar. Furthermore, the evaluation of the optimized membrane reveals that it costs only 81.6 USD m⁻², making it an effective and affordable solution for industrial wastewater treatment.

Keywords: Membrane; Polystyrene; Zeolite; Ultrafiltration; Dye.

Fenton degradation of Dye Organic Pollutant on Iron-doped natural Sand: Eco-Friendly Preparation, Characterization and Optimization of its Catalytic Activity

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Abstract

Continuous discharge of organic dyes into freshwater provides a long-term risk to the environment. Pollutants like dyes in textile effluent are both adsorbed and degraded by the advanced oxidation Fenton process. In this study, iron-doped sand (Si-Fe) was prepared, as an inexpensive catalyst, to rapidly eliminate methylene blue (MB) from aqueous solution. This material was characterized using different structural and morphological techniques. The Fenton-like degradation was optimized thanks to the response surface methodology, considering four input variables: initial MB dye concentration (5–35 mg.L⁻¹), Si-Fe dose (0.33–1 g.L⁻¹), pH (2–12) and H₂O₂ dose (2–8 mL.L⁻¹). The optimal conditions, MB concentration = 5 mg.L⁻¹, Si-Fe dose = 0.745 g.L⁻¹, pH = 7.909, and H₂O₂ dose = 5 mL.L⁻¹, allow to achieve maximum degradation (95.31%) and efficient reuse of the material over five cycles (>83%). Furthermore, the performance of Si-Fe was assessed in the treatment of textile wastewater using the Fenton process. Under optimal operating conditions, the system demonstrated an almost complete removal of color and conductivity, accompanied by a significant reduction in the effluent's organic load and turbidity (>70%). These results confirm the potential of Si-Fe as an eco-friendly, durable, and cost-effective catalyst for wastewater treatment.

Keywords: Iron-doped sand, Methylene blue, Textile wastewater, Fenton process, Experimental Design Methodology

Efficient Elimination of Recalcitrant Chloramphenicol Using PES/Clay Mixed Matrix Membranes: Experimental and Computational Study

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Abstract

Polyethersulfone/montmorillonite (PES/MMT) mixed matrix membranes were fabricated using the phase inversion method to assess their efficiency in removing the antibiotic chloramphenicol (CAP) from aqueous solutions. Membranes with different MMT loadings (M0 = 0, M1 = 1 wt%, M2 = 1.5 wt%, and M3 = 2 wt%) were systematically characterized to evaluate the influence of clay content on structural, physicochemical, and filtration properties. The incorporation of MMT progressively enhanced membrane hydrophilicity, reducing the contact angle from 75.9° for pristine PES (M0) to 56.8° for M3, while increasing surface energy from 44.76 to 55.75 J·m⁻². Pore size analysis revealed a substantial increase in mean flow pore size from 67.3 nm (M0) to 583.3 nm (M3), attributed to accelerated phase inversion dynamics. Mechanical testing showed that moderate clay loadings (M1 and M2) reinforced the polymer matrix, improving Young's modulus and tensile strength, whereas excessive loading (M3) caused nanoparticle aggregation and reduced mechanical strength.

Water permeability increased with MMT content up to 1.5 wt% (M2 = 269.17 m²·h⁻¹·bar⁻¹), but declined at higher loadings due to structural densification. Among the membranes, M1 demonstrated the best overall performance, achieving 87% CAP removal and a flux recovery ratio (FRR) of 78%, compared to 56% and 57.6% for M0. Computational analyses confirmed the experimental findings, revealing strong hydrogen bonding, electrostatic forces, and charge transfer between CAP and the MMT surface, along with decreased energy gaps and enhanced electrophilicity. The combined experimental and theoretical results establish PES/MMT mixed matrix membranes as efficient, sustainable, and cost-effective materials for advanced water purification applications.

Keywords: Polyether sulfone/montmorillonite mixed matrix membranes; Chloramphenicol removal; Antifouling property; Adsorptive-separation mechanism.

Improved Generation and Stability of ZnO Nanoparticles on Modified Clay for Advanced Textile Wastewater Treatment

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Abstract

Textile wastewater (TWW) often contains dyes that are difficult to remove and typically require costly, intensive treatment processes. Among available water treatment technologies, photocatalysis has emerged as a promising, efficient, and cost-effective alternative. However, improving photocatalyst performance for dye degradation in real TWW remains a major challenge. In this study, a novel photocatalyst was synthesized via a simple in situ method, involving the immobilization of zinc oxide (ZnO) onto polyethylenimine-modified montmorillonite, yielding a nanocomposite (ZnO@HNCs) designed for photocatalytic applications. Polymer bonding and intercalation promoted high dispersion and facilitated the formation of a homogeneous, stable ZnO coating layer. The structural and morphological features of the nanocomposite were characterized using FTIR spectroscopy, X-ray diffraction (XRD), scanning electron microscopy (SEM), and X-ray photoelectron spectroscopy (XPS). Photodegradation efficiency was evaluated using Blue Basic 41 (BB41) dye under ultraviolet irradiation. Optimization of the UV degradation process was performed through response surface methodology (RSM), considering three input variables: catalyst loading (0.2–0.6 g·L⁻¹), initial BB41 concentration (5–15 mg·L⁻¹), and pH (2–10). The optimal conditions—catalyst loading of 0.4 g·L⁻¹, initial dye concentration of 5 mg·L⁻¹, and pH 6—resulted in a degradation efficiency of 95%. Free radical scavenging assays confirmed that hydroxyl radicals (•OH) and photogenerated holes (h⁺) were the primary reactive species responsible for BB41 conversion. The hybrid nanocomposite ZnO@HNCs demonstrated high efficiency in removing BB41 and showed strong potential for the removal of other pollutants from aqueous solutions, highlighting its promise as a sustainable photocatalyst for textile wastewater treatment.

Keywords: Polyethylenimine; Immobilization of ZnO on clay; Optimization of photocatalysis process; Basic Blue 41 dye; Textile wastewater.

Sustainable adsorption of diclofenac sodium from water using orange peel-based activated carbon

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Abstract

In the environment, residual pharmaceuticals are a type of developing pollutants that damage human health. One of the famous widely produced and used anti-inflammatory drugs globally is diclofenac sodium (DCF), which is commonly found in water bodies. Among the water treatment processes, adsorption is an easy and efficient process. Recently, bio-based carbons obtained from eco-friendly biomass materials have received considerable attention. In the current work, a novel Orange peels activated carbon (OPAC) was prepared and examined as an adsorbent to eliminate DCF from an aqueous solution. Initially, OPAC was characterized by determining its physio-chemical properties. It clear that OPAC exhibited notable characteristics like high specific surface area of 779.05 m²/g, mesoporous structure and acidic properties. During adsorption procedure, the best operating conditions for DCF elimination by OPAC were pH 6, contact time of 25 min, temperature of 25 °C, biosorbent dose of 0.2 g.L⁻¹ and initial concentration of 25 mg.L⁻¹. The Langmuir isotherm model fitted better the experimental data than Freundlich model. The adsorption capacity determined by Langmuir model was $q_e = 86.68 \text{ mg g}^{-1}$. The DCF adsorption presented a pseudo-second order kinetics and the study of thermodynamic parameters revealed that the adsorption of DCF on OPAC is endothermic and spontaneous.

Keywords: Biosorbent, Orange peels, Adsorption, Diclofenac removal, Activated carbon

Towards Circular Water Management: Artificial Ecosystem and Phytoremediation for the Rehabilitation of the ERym Wetland (Annaba, Northeast Algeria)

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Abstract

Background and Problem Statement: Located in Northeastern Algeria, the ERym wetland in Annaba represents a vital coastal ecosystem currently under siege from rapid urbanization and the discharge of untreated wastewater. This sustained degradation not only compromises local biodiversity but also undermines the city's natural resilience against flooding. This case study proposes a tangible rehabilitation strategy rooted in the principles of a circular economy to restore the site's ecological and social value.

Project Description: The proposed intervention involves the establishment of an artificial ecosystem designed as a green treatment infrastructure. The system relies on a series of phytoremediation basins utilizing indigenous plant species and specialized filtering substrates. A distinctive feature of this study lies in the integration of specific substrates and green energy solutions, ensuring energy autonomy and a carbon-neutral footprint for the wetland area.

Objectives and Methodology: The methodological framework involved a comprehensive analysis of the water's physicochemical and bacteriological parameters to accurately dimension the Constructed Wetlands (CW). The objectives are twofold: to ensure the effective purification of urban runoff and peripheral wastewater, while simultaneously restoring the wetland's core ecological functions, specifically its hydrological regulation and its role as a biological habitat.

Expected Results and Impacts: Design simulations and pilot studies indicate that this intervention could transform a degraded discharge zone into a source of high-quality reclaimed water. This resource is intended for irrigating Annaba's green belts or maintaining the wetland's water levels during dry seasons. Beyond water quality improvements, the project envisions the creation of an ecological corridor and an environmental education hub, reconnecting the local community with their natural heritage.

Conclusion: The ERym case study demonstrates the viability of Nature-Based Solutions (NBS) in addressing urban environmental crises in Algeria. It offers a replicable model for circular water management in other Mediterranean wetlands facing similar anthropogenic pressures.

Keywords: Case study, ERym, Circular management, Phytoremediation, Water reuse, Urban resilience, Annaba.

Sustainable treatment of aquaculture wastewater using Solar-driven Advanced Oxidation Process at neutral pH

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Abstract

Pollution from aquaculture, industry and agriculture is putting an increasing strain on this finite supply of freshwater. Because of its complex composition, which includes organic matter, minerals, pharmaceutical residues (such as antibiotics) and pathogenic bacteria, aquaculture wastewater, in particular, poses a serious environmental risk. The inability of traditional wastewater treatment methods to effectively eliminate persistent organic contaminants emphasizes the need for innovative and environmentally friendly treatment technologies. This study explored the treatment of an aquaculture effluent to remove representative organic contaminants (caffeine, sulfapyridine, sulfamethoxazole, trimethoprim and flumequine) by a solar driven photo-Fenton-like process at neutral pH. This method takes advantage of natural solar irradiation to maintain the Fe(III)/Fe(II) redox cycle while enhancing radical-based oxidation. In order to facilitate the generation of the reactive sulfate radicals to the efficient degradation of resistance substances at neutral pH, persulfate activation mediated by a commercial iron fertilizer (Fe³⁺-IDHA) based on iminodisuccinic acid (IDS) complex was used. The biodegradable complex would increase iron stability at neutral pH, inhibit precipitation, and maintain catalytic activity during the treatment process.

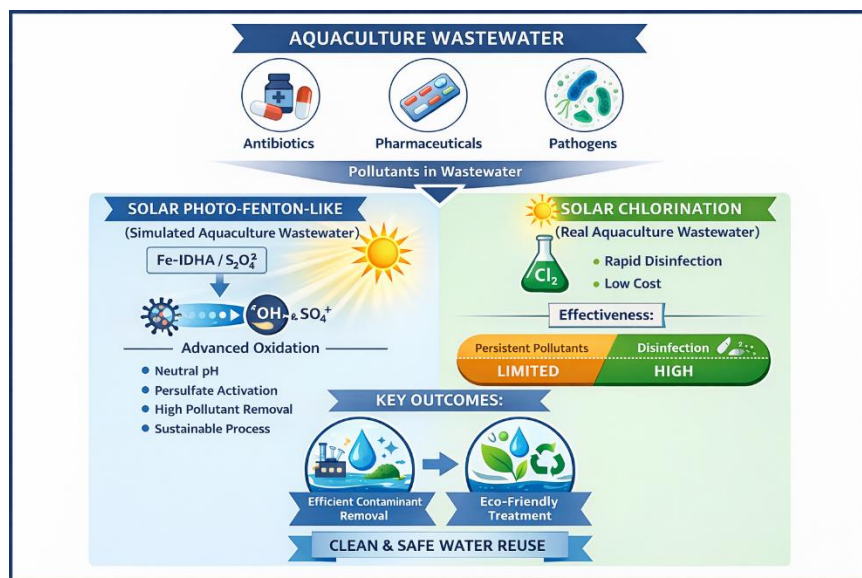
Water chlorination is a frequently used procedure for wastewater disinfection because of its high microbial inactivation effectiveness with a low cost of operation, but it shows a limited efficiency to remove organic contaminants. The limit of using only chlorination towards persistent organic compounds, emphasizes the importance of advanced oxidation processes using solar energy as additional solutions for a thorough wastewater treatment. The match between chlorine absorption and solar spectra led to radical species generation (HO· and Cl·) which play a critical role in overcoming kinetic limitation observed under dark oxidation, greatly increasing pollutant removal rates, according to experiments performed using both simulated and real aquaculture wastewater.

A simulated aquaculture wastewater, prepared daily following a previously reported protocol, was used for the solar-driven photo-Fenton-like experiments, which were carried out under natural

sunlight in a magnetically stirred open glass reactor (water height of 5 cm and volume of 1.3L) for 60 minutes. Solar chlorination experiments were performed using real aquaculture wastewater, also under natural sunlight in a raceway pond reactor (water height of: 5cm and volume of :17 L), for the same treatment duration.

In all experiments, the initial concentration of each target contaminant was fixed at 100 µg/L. The degradation of target contaminants was analyzed by Ultra-Performance Liquid Chromatography with Ultraviolet-Diode Array detection (UPLC-UV-DAD).

The results showed that solar-driven Fe-based persulfate activation at neutral pH and solar chlorination to treat aquaculture wastewater are effective, simple, and environmentally friendly processes, pending a deeper study to determine true kinetics and efficiency under different operational conditions. The processes studied are promising for a future reuse of aquaculture wastewater, especially in regions where there is a lot of sun and water scarcity.



Keywords: Advanced oxidation process (AOPs), Aquaculture wastewater, Solar chlorination, Solar photo-Fenton, Persulfate activation.

Antioxidant activity of *Juglans regia* L. Extracts and their Applications in Water Treatment

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Abstract

Natural plant products are becoming more and more essential in helping to promote safe well-being worldwide, in environmental protection and in water treatment [1].

Walnut shells (*Juglans regia* L.), often considered agricultural waste, are emerging as a rich source of natural antioxidants. These hard outer shells contain high levels of phenolic compounds, flavonoids, and lignin derived polyphenols that contribute to potent free radical scavenging activity which can contribute as antiscalants substances [2].

This work is aimed at evaluating the antioxidant capacity of hydro-ethanolic extract of walnut shells cultivated in Béjaïa, focusing on determining their content of phenolic compounds, flavonoids, and tannins, as well as their antioxidant activity using the DPPH (2,2-diphenyl-1-picrylhydrazine) assay. The extracts obtained were analyzed by atomic absorption spectroscopy (AAS), and high-performance liquid chromatography (HPLC). The results obtained will allow for a better understanding of the potential of these plants and will facilitate their application in water treatment processes, in health, food, and cosmetics sectors.

The result of the total polyphenol assay was 22.71 ± 2.02 mg GA eq/g and the quantification of flavonoids yielded value of 13.95 ± 4.17 mg QE/g of dry extracts. Determination of the condensed tannin content using the vanillin-HCl reaction allows to find a value of 82.4 ± 6 mg Cq/g. The study of antioxidant capacity using the DPPH method confirmed the potent properties of the phenolic compounds in the hydro-ethanolic extract. This extract exhibited excellent levels of inhibition, estimated at 87.28% at a low extract concentration of 20 µg/mL. A result is confirmed by its IC₅₀ value of 4.98 µg/mL.

The structures of the phenolic compounds were evaluated by high-performance liquid chromatography, comparing the retention times of standard phenolic acids, flavonoids, and tannins with our chromatogram results. The extract contained gallic acid, quercetin, catechin and juglanin.

A test of this extract as a scale inhibitor was carried out and the result is more promising. A mechanism of inhibition was then proposed.

Keywords: Antioxidant activity, polyphenols, *Juglans regia* L., environment, water treatment

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Self-combustion CeO₂ Nanoparticles as a Multifunctional Catalyst: Photodegradation of Hazardous Pollutants (Nitrobenzene & methyl red) and Antioxidant Activity

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Abstract

The study explores the photocatalytic and antioxidant properties of cerium oxide (CeO₂) nanoparticles synthesized via a self-combustion method. This approach yields highly crystalline, phase-pure CeO₂ nanoparticles with a cubic fluorite structure, confirmed through XRD, SEM, FTIR, and BET analyses. The nanoparticles exhibit a specific surface area of 46.3 m²/g, a bandgap energy of 2.85 eV, and a mesoporous nature with uniform particle size distribution (~0.21 μm), as well as remarkable reactivity and photocatalytic performance. Photocatalytic activity was assessed using Methyl Red and Nitrobenzene as model pollutants under UV, visible, and solar irradiation. CeO₂ achieved degradation efficiencies of up to 90% for Nitrobenzene under solar light and 69.3% for Methyl Red under visible light, following pseudo-first-order kinetics. Scavenger tests identified hydroxyl radicals as the dominant reactive species driving the degradation process. CeO₂ retained significant photocatalytic efficiency over multiple reuse cycles, demonstrating commendable stability and reusability. The antioxidant potential of CeO₂ was evaluated via DPPH radical scavenging, yielding an IC₅₀ value of 2.24 mg/mL, indicative of notable antioxidative properties. These results underscore the potential of CeO₂ as an efficient, sustainable material for environmental remediation and biomedical applications. The study highlights the importance of nanoparticle morphology and structural characteristics in optimizing performance across diverse operational conditions.

Keywords: Ceria, Methyl Red, Nitrobenzene, Photocatalysis, Self-combustion, Wastewater treatment,

Sustainable green synthesis of iron oxide nanoparticles for efficient dye adsorption from wastewater

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Abstract

In this work, Artemisia herba-alba extract was used to prepare magnetic Fe₃O₄ iron oxide nanoparticles by green chemistry. Characterisation by XRD, EDX, and SEM techniques showed that the green-synthesised iron nanoparticles are crystalline and porous, of magnetite type, with sizes ranging from 29 to 55 nm. The essential oil of Artemisia herba-alba was analysed by FTIR and GC/MS, revealing the presence of the phenolic compounds required for the protocol used to prepare the nanoparticles. Application of magnetic iron oxide nanoparticles to the adsorption of methylene blue dye using two different protocols (with and without ultrasonic irradiation) showed that the adsorption power of Fe₃O₄ nanoparticles, due to their porosity visualised by SEM and ultrasonic irradiation, gives a better adsorption rate of methylene blue.

Keywords: nanoparticles, iron oxide, green chemistry, plant extracts, dyes.

Optimization of the Extraction and Valorization Process of Humic Substances Derived from Compost

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Abstract

This study investigates alternative methods for extracting humic substances from compost using pure water as a solvent, combined with ultrasound and microwave-assisted extraction techniques. These approaches were compared to conventional alkaline extraction using sodium hydroxide. Results show that the assisted extraction methods achieve comparable yields of humic substances, with the highest total organic carbon (TOC) obtained through ultrasound extraction combined with maceration. Spectroscopic analyses confirm the presence of key functional groups (hydroxyl, carboxyl, and aromatic), ensuring the quality of the extracts without the use of harmful chemicals.

Furthermore, the extracts enhance wheat seed germination, particularly those obtained by microwave extraction combined with maceration, due to the improved release of essential nutrients such as phosphorus and potassium. This environmentally friendly approach reduces the risk of chemical pollution and demonstrates strong potential for industrial scale-up in compost valorization, offering a sustainable and innovative solution within green technology applications.

Keywords: Humic substances; compost extraction; green technology; sustainable extraction; Industrial scale-up.

Eco-Friendly Chromium Removal from Tannery Wastewater Using Electrocoagulation and Prickly pear mucilage cladode powder Flocculant

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Abstract

This study investigates the effectiveness of **electrocoagulation (EC) coupled with Prickly pear (Opuntia ficus-indica) cladode powder** for the removal of chromium from **real chrome tanning wastewater**. The experiments were carried out in a **batch stirred electrocoagulation reactor** equipped with **two aluminum electrodes**, aiming to evaluate the combined effect of electrochemical treatment and a natural bio-flocculant.

The influence of key operational parameters, including **electrolysis time, current density, initial pH of the effluent, and Prickly pear cladode powder concentration**, was systematically examined in order to optimize chromium removal efficiency. The results demonstrated that the coupling of electrocoagulation with Prickly pear cladode powder significantly enhanced chromium removal compared to electrocoagulation alone, highlighting the synergistic role of the natural flocculant in improving pollutant aggregation and separation.

Under optimal operating conditions, the chromium concentration in the treated effluent was successfully reduced to **levels compliant with environmental discharge standards**. However, for highly concentrated tannery wastewater, an extended treatment time of approximately **200 minutes** was required at a **current density of 200 A/m²** to achieve satisfactory removal efficiency.

In addition to treatment performance, **energy consumption** was evaluated to assess the feasibility of the proposed process. The results indicate that although prolonged electrolysis time increases energy demand, the use of Prickly pear cladode powder contributes to improving process efficiency, thereby making the combined EC–bioflocculation approach a **promising and**

eco-friendly alternative for the treatment of chromium-rich tannery effluents.

Keywords: Prickly pear cladode powder; Chromium; Electrocoagulation; Adsorption; Energy consumption.

3D well planning and design for salinity-temperature inferred by geological related seismic-geophysical models in water desalination and geothermal exploration

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Abstract

3D salinity-temperature mapping using wellbore trajectories and planning reveals a major challenge in the design production drilling for water salinity identification and their implication in geothermal potential. This work consists of developing of a new 3D inferred approaches using geologic, geophysics, hydraulic, and seismic attributes relationships in the coastal aquifer of Oued Taoui – Ain Temouchent situated in the Northwest of Algeria. The methodology integrates primarily the modified ambient temperature calculation of the Land Surface Temperature (LST) retrieved from the Landsat8 OLI/TIRS satellite imagery, and implemented in the Fourier formula according to the aquifer depth. Secondly, we have performed optimized well trajectories according to the thermal salts anomalies that are difficult to access with traditional drilling and overfitted expensive heat pumps for water desalination impact. In order to assess the water energy connection, the groundwater and geology interaction is difficult to produce scalable and robust results without integrating the physical parameters which serve as prominent for sustainable desalination and water reuse implication. In this context, we have developed a synergically interaction between geomaterial and seismic attributes such us velocities (V_p , V_s , dynamic and static Elasticity (Young Model), Poisson module, etc.). Indeed, the ratio (V_p/V_s) analysis made it possible to optimize the 3D directional drilling route to avoid high-risk areas, ensuring the technical and environmental viability of the desalination project. Thirdly, we have integrated the geophysical technique to infer the local incertitude of water salinity with regional thermal anomaly in order to enhance the effective tendency of saltwater regarding the hydraulics parameters extracted by simulated seismic and geophysical attributes. Finally, all the embedded models from geology, geophysics, seismics, and hydraulics were mapped using 3D geostatistical environment assuming more adjusted regression model with best optimized well trajectories for

water desalination. The implementation of trajectory algorithms (minimum curvature and Mercury, DogLeg Security (DLS), drag and torque impact) optimizes the trajectories that are confident from temperature and salinity affecting the seismic velocities and improving the planning well design simulation. The results indicated that 3D salinity-temperature mapping inspired from multiples modeling techniques are pivotal keys for geostructures system such desalination station dimensioning, and water reuse and preservation.

Keywords: 3D salinity-temperature mapping, geothermal potential, well planning, 3D Geological modeling, seismic attributes.

A Green Route to Water Security : Remediating Saline Water using Bio-Synthesized Perovskite

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Abstract

The development of sustainable materials for water desalination is a critical challenge. This work presents a green synthesis of samarium ferrite nanoparticles using lemon as a bio-fuel and complexing agent. This innovative protocol achieves crystallization at a reduced temperature, offering a lower-energy alternative to conventional synthesis routes. The nanoparticles demonstrated good efficiency in treating saline water, releasing a 75% reduction in salinity and a 60% decrease in electrical conductivity under optimized conditions. In particular, efficient elimination of aluminum (100%), cobalt (62%) and magnesium (32%) was achieved, alongside significant reduction of boron. This good performance is attributed to a synergistic removal process, driven by the engineered organic-inorganic interface of the nanoparticles. This unique interface facilitates the action of three key mechanisms: surface complexation, ion exchange and precipitation. The results establish green SmFeO_3 as a highly effective and sustainable nanomaterial for saline water remediation.

Keywords: Green synthesis, Perovskite, Water desalination, Nanoparticles, Sustainable remediation.

Advanced Materials for Environmental Protection and Ecological Remediation

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Abstract

Water pollution, particularly from industrial effluent discharge, poses serious threats to ecosystems and public health. The release of untreated or inadequately treated waste introduces excessive organic pollutants, measured as Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD), into aquatic systems. In this study, cobalt ferrite (CoFe₂O₄) nanoparticles were synthesized via the combustion method and investigated as functional materials for wastewater remediation.

Structural and physicochemical characterizations confirmed the successful formation of cobalt ferrite nanoparticles. X-ray diffraction (XRD) revealed a single-phase spinel structure. Fourier Transform Infrared Spectroscopy (FTIR) identified characteristic metal–oxygen vibrational bands and Scanning Electron Microscopy (SEM) showed a porous morphology favorable for adsorption and catalytic activity.

The synthesized nanoparticles were applied to real wastewater samples to assess their efficiency in reducing COD and BOD. Without magnetic coupling, the nanoparticles achieved removal efficiencies of 72% for COD and 73% for BOD. When a high-intensity magnetic field was coupled with the nanoparticles, the removal performance significantly increased to 87% for COD and 88% for BOD, corresponding to an improvement of approximately 15%. The application of the magnetic field enhanced nanoparticle dispersion, pollutant–surface interactions and facilitated efficient magnetic separation.

These results highlight the strong potential of magnetically activated cobalt ferrite nanoparticles as efficient and sustainable materials for wastewater treatment and environmental remediation.

Keywords: Cobalt ferrite, Wastewater remediation, COD/BOD removal, Nanoparticles, Magnetic separation.

Eco-Friendly Adsorption of Congo Red and Methylene Blue with Raw Carbon from *Posidonia oceanica*

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Abstract

The release of synthetic dyes into aquatic environments poses a serious environmental threat due to their toxicity, persistence, and resistance to biodegradation. Among these, Congo Red (CR) and Methylene Blue (MB) are frequently detected in industrial effluents. In this study, a raw (non-activated) carbon derived from *Posidonia oceanica* and carbonized at 700 °C was evaluated as a low-cost, eco-friendly adsorbent for the removal of CR and MB from aqueous solutions. Batch adsorption experiments were carried out to investigate the effects of initial dye concentration and solution pH on adsorption performance. Adsorption capacity increased with higher dye concentrations, reaching saturation at elevated levels. CR showed greater adsorption affinity than MB, and the process was strongly pH-dependent: acidic conditions favored CR removal. In contrast, MB adsorption was enhanced under alkaline conditions, highlighting the significance of electrostatic interactions. Kinetic analysis indicated that adsorption followed a pseudo-second-order model, suggesting that surface interactions govern the process. Equilibrium data fitted the Langmuir isotherm model, implying monolayer adsorption on a relatively homogeneous surface. These findings demonstrate that raw carbon derived from *Posidonia oceanica* is an effective, sustainable, and environmentally friendly adsorbent for the treatment of dye-contaminated wastewater. This approach not only offers a low-cost solution but also valorizes marine biomass waste, supporting circular economy principles in wastewater management.

Keywords: Raw carbon, *Posidonia oceanica*, Congo Red, Methylene Blue, Wastewater treatment.

Desalinated seawater for phosphate processing as a key to maintaining the sustainability of the mountain oases of Tamerza, Chebika, and Mides in southwestern Tunisia

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Abstract

The mountain oases of Tamerza, Chebika, and Mides in southwestern Tunisia rely on perennial springs fed by fossil groundwater from the Continental Intercalaire and Complex Terminal aquifers, including the Miocene Beglia Formation, which support both traditional gravity irrigation and high-value Deglet Nour date production. Since the 1950s, extensive groundwater abstraction for phosphate extraction and washing in the Moularès–Redeyef basin, along with agricultural expansion and climate-driven aridification, has caused a significant decline in piezometric levels, spring discharge, and water quality, accelerating soil salinization, biodiversity loss, and the emergence of new date palm pests. This work argues that a strategic, large-scale shift from fossil groundwater to desalinated seawater for mining and industrial uses is the most effective solution to reduce pressure on the aquifers that supply the oases, thereby preserving natural springs and the ecological services they provide.

Keywords: Tamerza oases; Oases sustainability; Perennial springs; North Western Sahara Aquifer System; Traditional irrigation system; Groundwater overexploitation; Spring discharge; Desalinated seawater

Sustainable treatment of contaminated water for reuse using bio-based activated carbon from *Leucaena* leaves: Cadmium adsorption study

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Abstract

The aim of this research was to decontaminate cadmium polluted water using a low-cost bioadsorbent (modified leucaena leaves). *Leucaena* is a tree that is abundant throughout the year in the town of Mostaganem in north-western Algeria. *Leucaena* leaves have been transformed into an easily obtained activated carbon. Characterization of activated carbon *Leucaena* leaves (ACLL) was determined by SEM, FTIR and XRD. The adsorption performance of this new biosorbent to remove Cd²⁺ was evaluated under the following operating conditions: Biomass dose, equilibrium time, initial cadmium concentration, pH and temperature. Maximum adsorption capacity was obtained at a pH of 4, a biosorbent dosage of 0.6 and a contact time of 90 min. The Langmuir adsorption isotherm proved most compatible with experimental equilibrium data, with a maximum adsorption capacity of 28 mg/g. The pseudo-second-order model was well adapted to the kinetic results (R²=0.99). Thermodynamic characteristics showed that cadmium adsorption was an endothermic and spontaneous process. In the light of these results, ACLL has great potential for the treatment of water polluted by heavy metal cadmium.

Keywords: Desalination, Cadmium, Bio-adsorption, *Leucaena* leaf, kinetics

A Sustainable Route to NiFe₂O₄ Nanoparticles: Application in Water Treatment and Agriculture

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Abstract

The present work details the sustainable synthesis and multifunctional application of NiFe₂O₄ nanoparticles for environmental remediation and agricultural water reuse. The nanoparticles were successfully prepared via a green route using lemon peels as a low-cost biological agent. Following calcination at 700 °C, structural characterization, including X-ray diffraction (XRD), Fourier-transform infrared (FT-IR) spectroscopy and Raman spectroscopy, confirmed the formation of a well-crystallized spinel phase. Morphological analysis revealed homogeneous spherical nanoparticles. Saline water treatment tests demonstrated the material's effectiveness, achieving up to 80% salinity reduction. The improved water quality alleviated osmotic and ionic stress in the plants. This resulted in significantly enhanced barley seed germination and uniform early-stage growth. These findings validate the potential of the green nanomaterial for sustainable agricultural water reuse.

Keywords: Nanostructure, NiFe₂O₄, Green remediation, Agricultural reuse.

Catalytic Degradation of Triclosan Using Fe/ZrO₂ and Fe-Co/ZrO₂ Systems in Waste Water treatment

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Abstract

The objective of this work was to study the catalyzed wet oxidation reaction with metal catalysts based on iron supported on Zirconia oxide and bimetallic catalysts based on cobalt and iron deposited on ZrO₂, in order to degrade one of the endocrine disruptors: Triclosan.

In this study, we used the sol-gel route for the development of airgel supports. These supports are then used to prepare a series of catalysts based on iron alone or on iron and cobalt with fixed percentages by dry impregnation. All these catalysts are reduced under hydrogen flow at 300°C. The study of the textural and structural properties of the solids was carried out by measuring the specific surface by the BET method and by TPR. The N₂ adsorption-desorption analysis of the different solids shows similar isotherms with the ZrO₂ support, with varied hysteresis loops which reflects different textures and porous distributions.

The TPR-H₂ profiles show the non-reducibility of ZrO₂. The TPR analysis of the catalysts shows characteristic peaks of the reduction of iron and cobalt. The results of the catalytic tests show that the monometallic catalyst based on Iron supported on ZrO₂ and the bimetallic catalyst impregnated simultaneously on the ZrO₂ support exhibit significant catalytic activity in the degradation of Triclosan. This seems to be due to an increase in the average pore diameter and the pore volume, which results in a better iron-support interaction and therefore a good dispersion of the metallic phase at the ZrO₂ surface.

Key words: Triclosan., Oxidation, Catalysts, Environment.

Green production of SnO₂ nanoparticles from lignocellulosic biomass: Adsorption of a hazardous anionic dye, kinetic and thermodynamic investigation.

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Abstract

The growing environmental pollution caused by synthetic dyes is a major problem. They significantly deteriorate water quality and pose a major threat to the aquatic system and human life. The aim of the present study was to synthesize a tin oxide nanocomposite based on a lignocellulosic biomass (*Acacia saligna* leaves) in order to use it effectively as a nanoadsorbent for the removal of an anionic dye (Methylorange). SnO₂ nanoparticles (SnO₂-NPs) were characterized by Fourier transform infrared FTIR, X-ray diffraction and scanning electron microscopy. The SnO₂-NPs adsorption process for Methylorange dye removal was studied in a batch system. The main parameters of the adsorption system are : Solution pH, equilibrium time, dose, dye concentration and temperature. The Langmuir adsorption isotherm was found to be most consistent with experimental equilibrium data, with a maximum adsorption capacity of 76 mg/g. The pseudo-second-order model was fitted by the kinetic data ($R_2=0.99$), which took 100 minutes to reach equilibrium. Thermodynamic parameters showed that Methylorange adsorption was an endothermic and spontaneous process. Based on these results, SnO₂-NPs is of great interest for the treatment of water contaminated by dyes.

Keywords: Nanoparticules SnO₂, *Acacia saligna* leaves, Méthylorange, Depollution, Green chemistry.

Parametric Numerical Analysis of the Thermal Behavior of a PCM-Integrated Plate Heat Exchanger

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Abstract

Latent thermal energy storage is an effective solution to improve the thermal stability and performance of energy systems. The integration of phase change materials (PCM) into plate heat exchangers represents a promising approach for thermal energy storage and controlled heat management, particularly for low- and medium-temperature applications such as humidification–dehumidification (HDH) desalination systems.

This study presents a transient two-dimensional numerical investigation of the thermal behavior of a PCM-integrated plate heat exchanger designed for HDH applications, with a particular focus on the melting and solidification processes of the PCM during thermal charging and discharging phases. The temporal evolution of temperature fields, liquid fraction, and stored energy is analyzed under various operating conditions. A parametric study is conducted to assess the influence of the fluid inlet temperature, the initial PCM temperature, and the flow velocity on the thermal performance of the system.

The numerical results show that the thermal response and storage efficiency of the exchanger are primarily governed by the initial thermal gradient between the heat transfer fluid and the PCM. High inlet water temperatures (up to 75 °C) lead to capacity ratio values approaching 0.99, indicating an accelerated charging process and a high level of energy storage. Configurations combining hot inlet water, an initially cold PCM (25 °C), and a higher flow velocity (0.035 m/s) allow the PCM to reach a capacity ratio close to unity, corresponding to an almost fully charged storage state. These operating conditions significantly enhance the rate of enthalpy increase and reduce thermal fluctuations of the heat transfer fluid.

The study highlights the potential of PCM-integrated plate heat exchangers as an effective

solution for thermal management and energy storage in HDH desalination applications. The developed numerical model provides a useful tool for assessing the impact of operating conditions on thermal performance, and future experimental work is planned to validate the numerical findings and optimize the proposed configuration under practical HDH operating conditions.

Keywords: PCM, Heat Exchanger, HDH, Latent Heat Storage, Numerical Study

Cu-Pyromellitic acid-MOF/Chitosan composite for wastewater treatment: dyes and heavy metals adsorption study and pathogenic antibacterial properties

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Abstract

The Cu-Pyromellitic Acid-MOF composites based on chitosan biopolymer (Cu-PMA/CS) were successfully synthesized and identified using multiple characterization analyses: FTIR, XRD spectroscopies and TG analysis. The Zeta potential shows that surface charges of composites have a higher negative charge higher than Cu-PMA MOF without chitosan. According to their charge values, Cu-PMA/CS was good candidate for the dye adsorption. The adsorbance capacity (q_{max}) of MB onto Cu-PMA/CS composites reached 265 mg/g and 325 mg/g, respectively. Results demonstrated a higher negatively charged-rich of the prepared composites towards cationic dyes like MB. Based on the practical experiments and analysis tools, the adsorption mechanism of MB onto Cu-PMA/CS is presumed to occur via electrostatic, π - π interaction and coordination bonds. Adsorption test reveals that the increasing of chitosan amount incorporated into the composites ameliorated the attraction between the composite and the colorant. In addition, the two prepared Cu-PMA/CS were employed as an adsorbent for the removal of Pb(II) ions from an aqueous solution. They exhibit high adsorption capacity values, the maximum of this value is about 780 mg/g corresponding an adsorption removal of 85,3%.

Ion exchange with the copper metal of the Cu-PMA/CS structure was determined as the key contributor to the adsorption of Pb(II) heavy-metal ions as well as its interactions with amines groups onto Cu-PMA/CS composite. The antimicrobial evaluation of Cu-PMA/CS composites was performed against several infectious bacterial strains and results indicated that they possessed strong antibacterial properties.

These results indicate that Cu-PMA/CS composites are a promising material in adsorption and removal of toxic dyes and heavy metal ions. So, they could be using as treatment of wastewater containing organic pollutants, heavy metal and bacterial contamination.

Keywords: Metal-organic framework; Chitosan; Methylene blue; Heavy metal; Kinetic adsorption, antibacterial properties.

Institutional Quality and Water Desalination Efficiency: Evidence for Mediterranean Region

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1. Cover page

The aim of this study is to assess the impact of institutional quality on the efficiency of water desalination processes in countries of the Mediterranean region.

This research is particularly significant for three main reasons. First, it addresses a critical knowledge gap in understanding how institutional quality affects the efficiency of desalination processes in the Mediterranean region, where water scarcity is a pressing challenge. This analysis will provide valuable insights into how different institutional frameworks can either enhance or impede the effectiveness of desalination operations. Second, as many regions worldwide increasingly turn to desalination as a solution to water scarcity, our findings will offer valuable lessons and policy recommendations that could be adapted to other geographical contexts facing similar institutional and environmental challenges. Third, by examining the relationship between institutional quality and desalination efficiency, this study will contribute to the broader discussion of how governance structures influence the balance between technological innovation, economic viability, and environmental sustainability in the water sector. Therefore, our study focuses on a sample of **201 desalination stations from 21 Mediterranean countries during the period 2015-2023, using panel regression analyses.**

Drawing from the **COP23 framework and sustainability commitments**, this study develops a comprehensive analytical framework that combines institutional quality metrics **with three key sustainability criteria** to evaluate the efficiency of the desalination sector. *First*, the **energy efficiency criterion** evaluates the energy consumed per m³ of water, including energy, maintenance, and labor expenses, in line with **COP23's** focus on emissions reduction and clean energy transitions under the Paris Agreement. The analysis will explore how institutional quality influences the adoption of energy-efficient technologies and renewable energy in desalination, supporting pre-2020 climate action goals. Second, we examine the **economic efficiency criterion**, which measures production costs per m³ of water. This criterion reflects COP23's

commitment to financial support for developing countries and the implementation of climate-resilient technologies. Our analysis considers how institutional frameworks influence cost optimization and resource allocation, with a focus on financial mechanisms highlighted in the COP23 agreements to support sustainable industrial development. Third, we analyze the **technical efficiency criterion** through the conversion rate, which measures the ratio of water produced to seawater used. This criterion aligns with the Talanoa Dialogue principles established at COP23, promoting knowledge sharing and best practices in climate-resilient technologies. The analysis will examine how institutional quality affects technological adoption and operational efficiency, while also considering the gender action plan adopted at COP23 by evaluating inclusive institutional frameworks that promote equal participation in technological development and implementation.

The Mediterranean region offers a captivating setting for this study for several reasons.

First, the region faces severe water stress, with the IPCC (2022) confirming that the Mediterranean is one of the world's most vulnerable regions to climate change and water scarcity. This water scarcity is compounded by rapid urbanization and population growth, particularly in the Southern Mediterranean countries where water demand has increased by more than 60% in the last 50 years (Plan Bleu, 2020). The region's water vulnerability is further exacerbated by climate change impacts, with increasing pressure on water resources across most Mediterranean countries (Plan Bleu & UNEP/MAP, 2019). Moreover, the Mediterranean's unique position as a meeting point between developed and developing economies provides an ideal setting for analyzing varying institutional frameworks. According to the World Bank's Governance Indicators (2023) and UNEP/MAP-Plan Bleu (2016), the region exhibits significant variations in institutional quality, ranging from highly developed regulatory systems in European countries to emerging governance structures in North African nations. This institutional diversity allows for relevant comparative analysis of how governance affects desalination outcomes. Furthermore, the Mediterranean's environmental sensitivity, characterized by its rich marine biodiversity and vulnerability to climate change, makes it crucial to understand how institutional frameworks can promote sustainable desalination practices (Plan Bleu, 2020). The regional outlook for sustainable water management, as outlined in the Mediterranean Strategy for Sustainable Development 2016-2025 (UNEP/MAP-Plan Bleu, 2016), emphasizes the role of institutional capacity in managing water resources efficiently. Finally, the Mediterranean region's commitment to addressing climate change and water challenges was reinforced through the Union for Mediterranean's participation at COP23, highlighting the need for regional cooperation in water management and climate action (UfM, 2019). This aligns with the Mediterranean Strategy for Sustainable Development 2016-2025, which emphasizes the importance of strengthening institutional frameworks for sustainable water management, including

desalination technologies (UNEP/MAP-Plan Bleu, 2016). The region's involvement in global climate discussions has led to increased focus on water-energy efficiency in desalination processes (Plan Bleu, 2020).

The **expected results** of this study are as follows: First we expect that higher institutional quality will enhance desalination efficiency, reducing energy consumption and costs while increasing conversion rates across various metrics. It is also expected that the relationship between institutional quality and efficiency will vary by technology type, with thermal technologies showing a more substantial impact. Key institutional components, particularly Government Effectiveness and Regulatory Quality, are anticipated to significantly influence economic and energy efficiency, while rule of law and control of corruption will affect operating costs. Additionally, differences between Northern and Southern Mediterranean countries are expected, with Southern countries likely experiencing greater benefits from improvements in institutional quality compared to their Northern counterparts.

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Comparative Adsorption of Murexide onto PANI, Activated Carbon, and PANI/AC Composite

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Abstract

This study investigates the adsorption behavior of an anionic organic dye, Murexide, onto three different adsorbents: polyaniline (PANI), activated carbon (AC) derived from the marine biomass *Posidonia oceanica*, and their PANI/AC composite. Activated carbon was synthesized through chemical activation of dried *Posidonia* residues using KOH, while the composite material was prepared via in situ oxidative polymerization of aniline in the presence of activated carbon. The synthesized materials were thoroughly characterized using FTIR spectroscopy, X-ray diffraction (XRD), scanning electron microscopy (SEM), thermogravimetric analysis (TGA/DTG), BET surface area analysis, and point of zero charge (pHPZC) determination to elucidate their structural, morphological, and surface properties. Batch adsorption experiments were carried out to evaluate the influence of key operational parameters, including solution pH, adsorbent dosage, contact time, initial dye concentration, and temperature. Adsorption kinetics, equilibrium isotherms, and thermodynamic analyses were employed to gain insight into the adsorption mechanisms and the interactions between Murexide molecules and the different adsorbent surfaces. This comparative approach aims to highlight the role of adsorbent nature and surface chemistry in the removal of anionic dyes from aqueous media.

Keywords: Polyaniline; Activated carbon; PANI/AC composite; Anionic dye; Adsorption.

Adsorption of Methyl Green onto a PANI/Activated Carbon Composite

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Abstract

This work focuses on the adsorption of Methyl Green, a cationic organic dye, from aqueous solutions using a composite material based on polyaniline (PANI) and activated carbon derived from *Posidonia oceanica* biomass. The activated carbon was prepared via KOH chemical activation of dried marine biomass, and the PANI/AC composite was synthesized through in situ oxidative polymerization of aniline in the presence of the activated carbon matrix. The composite was characterized using a range of physicochemical techniques, including FTIR, XRD, SEM, TGA/DTG, BET surface area measurements, and pHPZC analysis, to assess its structural features, thermal stability, and surface properties. Batch adsorption experiments were conducted to examine the effect of various experimental parameters such as pH, adsorbent dosage, contact time, initial dye concentration, and temperature on the adsorption process. Kinetic, isotherm, and thermodynamic models were applied to analyze the adsorption mechanism and the nature of interactions between Methyl Green molecules and the composite surface. This study aims to provide a comprehensive understanding of the potential of PANI/AC composites as efficient and sustainable adsorbents for the removal of cationic dyes from wastewater.

Keywords: Polyaniline/activated carbon composite; Cationic dye; Adsorption; Wastewater treatment.

Optimization of phosphorus treatment in wastewater by chemical means

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Abstract

Optimization of chemical treatment of phosphorus in wastewater aims to improve the efficiency of phosphorus removal by precipitation, using metal salts (Alumina Sulfate) to form insoluble compounds that can be easily removed.

This involves a thorough understanding of the chemical reactions involved and the interactions with the pollutants present.

The objective is to minimize the concentration of phosphorus in effluents, because its excess can lead to a proliferation of algae and aquatic plants, disrupting the ecological balance of aquatic environments. Removal of phosphorus from wastewater is therefore essential to prevent eutrophication and protect water quality.

Keywords: Wastewater, Adsorption, Water purification, Biological treatment, DBO₅.

Enhanced p-Nitrophenol Adsorption Using Bio-Derived Activated Carbon from *Opuntia ficus indica*: Characterization, Isotherms, Kinetics, and Regeneration

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Abstract

Activated carbon produced from *Opuntia ficus indica* via sodium hydroxide activation was utilized for the removal of p-nitrophenol from aqueous solutions. The structural and surface properties of the activated carbons were examined using Fourier transform infrared spectroscopy (FTIR), nitrogen adsorption measurements, scanning electron microscopy (SEM), and Boehm titration. The influence of key operational parameters including pH, contact time, adsorbent dose, and temperature on p-nitrophenol uptake was evaluated. Equilibrium data were interpreted through Freundlich, Langmuir, Temkin, and Dubinin-Radushkevich adsorption isotherm models, while thermodynamic characteristics of the adsorption process were also assessed. The adsorption of p-nitrophenol was determined to be spontaneous and exothermic, obeying a pseudo-second-order kinetic model, with the Langmuir isotherm yielding the most accurate representation of the equilibrium behavior at 15 °C. The activated carbon demonstrated strong affinity for p-nitrophenol, and regeneration studies revealed that the adsorbent retained more than 94 % removal efficiency after five consecutive adsorption–desorption cycles.

Keywords: Activated carbon, *Opuntia ficus indica*, adsorption, p-nitrophenol, isotherm, regeneration.

Use of capacitive deionization and membrane distillation for water treatment and resource recovery

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Abstract

Fast growth in world population added to increased industrialization and consumption has led to significant increase in waste generation, scarcity of clean water and depletion of natural resources. This research presents results of investigating treatment of wastewater using integrated membrane distillation as well as flow electrode capacitive deionization approaches for the simultaneous production of treated water and recovery of value-added products such as ammonia and phosphorus. The later is a non-renewable life sustenance element that not only is depleting rapidly but also leads to detrimental eutrophication of aquatic systems when discharged to the environment. The results showed the potential of using the technologies to recover treated water as well as concentrated phosphates and ammonia solutions from wastewaters for production of fertilizers and other products. In addition, an order of magnitude energy assessment showed that the systems can be more energy efficient than conventional approaches particularly when using renewable or low-cost energy or heat sources.

Keywords: Membrane Distillation, Phosphorus, Capacitive deionization.

Technical, economic and environmental study of a solar thermal installation

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Abstract

This work summarizes the approach of a detailed preliminary design study for the domestic hot water supply of a commercial establishment (hotel). The study begins with an estimation of the Domestic Hot Water DHW requirement based on historical consumption data. Considering local meteorological data, installation conditions (orientation, tilt, etc.), and the technical characteristics of the storage tank, heat exchanger, and solar thermal panels, A numerical calculation was performed to determine the coverage rate and productivity based on the panel surface area. The optimal surface area was then selected to size the pump, safety valve, expansion tank, and piping. The economic calculation, along with an evaluation of the return on investment (ROI), which is encouraging in this case even without government subsidies, allows the developer to justify their decision. Finally, the environmental impact was also assessed by calculating the amount of CO₂ avoided through the use of solar energy (carbon footprint).

Keywords: DHW, Solar thermal, Sizing, ROI, carbon footprint.

Ultra-rapid dual dye removal recyclable by highly efficient blue crab crustacean biochar

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Abstract

This research investigates the removal of Rhodamine B (RB) and Green Malachite (GM) dyes from synthetic and real wastewater using locally sourced crustacean biochar.

The biochar was prepared through hydrothermal carbonization followed by chemical activation. Adsorption performance was evaluated under both static and dynamic conditions, achieving removal efficiencies of 94.31% for (RB) and 97.24% for (GM) dyes, indicating that the crab shell biochar could ultra-rapid and highly efficient dyes adsorbent. The adsorption behavior was dye-specific, influenced by molecular structure and interactions with the adsorbent surface. The data were best fitted to the Freundlich isotherm model. These findings highlight the potential of crab shell biochar as a sustainable and effective material for dye removal from wastewater.



Biofouling of polyethersulfone membranes: an integrated biokinetic model for energy consumption optimization in an MBR system

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Abstract

Reduction of energy costs in flat-sheet membrane bioreactors (MBRs) is a significant area of research, particularly due to the high energy demand associated with fouling control and aeration processes [1, 2]. Understanding and effectively managing membrane fouling is therefore crucial for reducing overall energy consumption [3]. Numerous studies have highlighted the critical role of biopolymers, particularly soluble microbial products (SMP) and extracellular polymeric substances (EPS), in membrane fouling processes [4, 5]. The presence of biopolymers establishes a lower limit for effluent quality [6] and accelerates membrane fouling by affecting key sludge properties, including dewaterability, settleability, and compressibility [7]. Consequently, there is considerable interest in developing kinetic models that couple Activated Sludge Model No. 1 (ASM1) with biopolymer formation processes in order to improve predictive capability and better describe the influence of biopolymers on membrane fouling.

This study presents a new dynamic mathematical model, ASM1-SMP-EPS, which was successfully implemented and calibrated. The model extended the traditional ASM1 framework to explicitly incorporate soluble microbial products (SMP) and extracellular polymeric substances (EPS). Partial Least Squares (PLS) analysis was used to identify the most influential kinetic parameters affecting system performance. The results highlight the impact of incorporating S_{BAP} , S_{UAP} , and X_{EPS} pathways into the steady-state Activated Sludge Model No. 1 (ASM1). The inclusion of additional parameters such as γ_H , γ_A , f_{BAP} , and f_{EPS} significantly improved the model's predictive capability.

Furthermore, comprehensive sensitivity and uncertainty analyses resulted in a robust model capable of accurately simulating SMP and EPS dynamics, thereby enhancing membrane fouling prediction and supporting process optimization.

Keywords: membrane fouling, model-based control, energy minimization, Soluble microbial product/ extracellular polymeric substances, ASM1

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SnO and spinel ferrite nanoparticle electrodes for advanced electrochemical wastewater treatment

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Abstract

This work is dedicated to the development of stable and high-performance electrode materials for advanced electrochemical processes. Nanoparticles were synthesized via the co-precipitation method and subsequently employed in electrode fabrication. Structural analysis using X-ray diffraction (XRD) confirmed the formation of tin oxide (SnO) and ferrite spinel phases, namely $MnFe_2O_4$, $CoFe_2O_4$, and $SnFe_2O_4$. UV-visible spectroscopy further corroborated the successful synthesis of tin oxide nanoparticles and tin-based ferrite spinels. Laser particle-size analysis revealed a heterogeneous particle size distribution with predominantly polygonal morphology and particle sizes ranging from 2 to 10 μm . Electrochemical investigations demonstrated excellent stability of the prepared electrodes, with the $SnFe_2O_4$ -based electrode exhibiting superior electrochemical performance. As a practical application, the electrochemical degradation of a dye was investigated, and high-performance liquid chromatography (HPLC) analyses confirmed the promising potential of this electrode material for the treatment of industrial liquid effluents.

Keywords: Electrode materials; Ferrite spinels; Tin oxide nanoparticles; Electrochemical stability; Wastewater treatment

Valorization of Sebkha El Melah Brine: Synthesis and Characterization of Magnesium Oxide with Co-Product Recovery

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Abstract

This study contributes to the valorization of natural resources by presenting a method for producing magnesium oxide from natural brine sourced from Sebkha El Melah in Zarzis. The synthesis process involves sequential evaporation and chemical treatment steps to first remove sodium, potassium and sulfate ions, followed by precipitation of magnesium hydroxide. The hydroxide precipitate was washed, dried and calcined to yield the target oxide. Characterization of the final product confirmed the formation of a pure, well-crystallized MgO phase. The obtained powder exhibits agglomerated particles with a narrow, unimodal size distribution centered at 16 μm . The material possesses a mesoporous structure, characterized by a specific surface area of 87 m^2/g , a pore volume of 0.77 cc/g and an average pore diameter of 3.6 nm. Notably, the process facilitated the recovery of several useful by-products, improving its overall economic viability. Additionally, the final residual solution, still rich in sodium and chloride ions, presents opportunities for further valorization pathways.

Keywords: Valorization, Natural brine, Recovery, Magnesium oxide

Artificial Intelligence in the Water–Energy Nexus: Implications for Financial Performance in the CAC 40

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Abstract

While Artificial Intelligence (AI) has emerged as a transformative catalyst for financial performance, the underlying digital infrastructure demands intensive water and energy consumption, exposing firms to significant operational, regulatory, and ESG-related risks. This paper empirically investigates the impact of AI adoption through the lens of the water-energy nexus as a determinant of both accounting and stock market performance for companies listed on the CAC 40. Using panel data econometrics, we examine the correlation between AI integration intensity and corporate profitability. Our research addresses how the integration of AI influence corporate performance, revealing that while AI can enhance average profitability, this positive effect is significantly attenuated for firms highly exposed to hydric stress and energy price volatility. Furthermore, we demonstrate that companies implementing robust strategies to mitigate their environmental footprint through energy efficiency and enhanced ESG transparency benefit from superior market valuation and a statistically significant reduction in the cost of capital. The findings suggest that the environmental externalities of AI constitute a novel transmission channel for systemic risk within the financial sphere. This study provides critical implications for directors, investors, and regulators, advocating for more sophisticated capital allocation strategies and stringent extra-financial reporting to reconcile the digital transition with environmental sustainability.

Keywords: Artificial Intelligence, Water-Energy Nexus, Financial Performance, ESG Risk, CAC 40,

Efficient Removal of Congo Red Dye Using Iron-Pillared Bentonite: Optimization by Central Composite Design

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Abstract

This study explores the adsorption of Congo Red (CR) dye using iron-pillared bentonite. The material was prepared via iron intercalation to enhance its structural and adsorption properties and was characterized by X-ray diffraction (XRD), infrared spectroscopy (IR), and textural analysis (internal porosity and pore volume). Adsorption optimization was performed using Central Composite Design (CCD) to evaluate the effects of solution pH, contact time, adsorbent mass, initial dye concentration, and temperature. The results showed that adsorption efficiency strongly depended on these factors, with maximum CR removal achieved under acidic conditions. Optimal adsorption occurred at a contact time of 40 min, an initial dye concentration of 120 mg L⁻¹, an adsorbent mass of 0.1 g, and a temperature of 45 °C. These findings demonstrate that iron-pillared bentonite is an efficient, low-cost, and promising adsorbent for dye-contaminated wastewater treatment.

Keywords: Iron-pillared bentonite, Congo Red, adsorption, Central Composite Design, wastewater treatment, dye removal.

Adsorptive removal of lead and methylene blue using hybrid chitosan-clay adsorbants optimized by response surface methodology (central composite design)

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Abstract

Heavy metals and dyes in water represent serious environmental and health risks. Natural clays offer a low-cost and sustainable solution for their removal.

In this study, Tunisian clay was used as an adsorbent for lead removal and modified with chitosan at different clay/chitosan mass ratios (1:1, 2:1, 3:1). The adsorption process was studied by varying contact time and solution pH, and methylene blue was also tested to evaluate dye removal efficiency.

Lead adsorption was optimal under basic conditions, reaching 99.98 % for a clay/chitosan ratio of 1:3, while methylene blue (MB) removal reached 98.21%, demonstrating the effectiveness of chitosan modification. Response Surface Methodology (RSM) with a Central Composite Design (CCD) was used to model and optimize the effects of pH and contact time on lead removal efficiency.

Keywords: Adsorption, chitosan, clay, methylene blue, lead.

Assessment of Irrigation Water Quality Using Fuzzy Logic and Land Cover Dynamics in the Touggourt Region (Algerian Sahara)

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Abstract

Groundwater sustainability in the Algerian Sahara remains precarious, especially within the Oued Righ valley where farming is expanding rapidly. This research couples Remote Sensing (RS) with Fuzzy Logic to trace how land cover changes between 2017 and 2022 have influenced irrigation water quality. By leveraging Google Earth Engine and the SAVI index, we pinpointed an agricultural surge of **2,847 hectares** in the Touggourt area. We then cross-referenced this with a Fuzzy Water Quality Index (FWQI) built from 39 hydrochemical samples (covering EC, SAR, SSP, and Magnesium/Kelley ratios). The results present a striking contrast: while standard Wilcox and USSL plots label the water as a "High Salinity Hazard," the fuzzy model suggests it is actually "Permissible" (Mean FWQI \approx 52.8), likely due to local soil permeability and crop tolerance. Even under a "Business-as-Usual" projection through 2030, the aquifer shows surprising inertia, degrading only slightly to 54.09. We interpret this as a "Resilience Paradox"—the system is currently absorbing the shock, but this stability is likely temporary without the adoption of smarter irrigation practices.

Keywords: Fuzzy Logic, Terminal Complex (CT), Remote Sensing, Water Quality.

Comprehensive Optimization of Electrocoagulation Reactor Design Parameters for Sustainable Decolorization of Tunisian Olive Mill Wastewater: A Mechanistic and Statistical Approach

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Abstract

Olive mill wastewater (OMWW) represents one of the most challenging agro-industrial effluents due to its complex matrix of organic pollutants, intense coloration, and phytotoxic compounds. This study presents a comprehensive optimization of electrocoagulation (EC) reactor design parameters for efficient decolorization of Tunisian OMWW using a systematic mechanistic and statistical approach. A five-level Central Composite Design (CCD) was employed to investigate the synergistic effects of six critical operational parameters: electrode material, configuration, surface-to-volume ratio (S/V), inter-electrode distance, current density, and hydrodynamic conditions. Results demonstrated that aluminum electrodes in monopolar configuration achieved superior decolorization efficiency (95.8%) under optimized conditions (pH 7, current density 4.01 mA/cm², inter-electrode distance 3 cm, S/V ratio 76.8 m⁻¹, agitation speed 200 rpm). Kinetic analysis revealed pseudo-first-order behavior with a rate constant of 0.035 min⁻¹, while energy consumption was optimized at 0.9 kWh·m⁻³. Advanced characterization techniques (SEM-EDS, BET) confirmed that amorphous aluminum hydroxide flocs with high surface area (247.8-421.0 m²/g) were responsible for chromophore removal through adsorption-coagulation mechanisms. The optimized EC process provides a sustainable, reagent-free solution for OMWW treatment, with significant implications for Mediterranean olive oil-producing regions facing environmental challenges from seasonal wastewater discharges.

Keywords: Electrocoagulation optimization; Olive mill wastewater; Reactor design; Response surface methodology; Sustainable wastewater treatment; Aluminum electrodes.

Coupling Electrocoagulation with Activated Carbon Adsorption for Efficient Post-Treatment and Phenolic Removal from Olive Mill Wastewater

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Abstract

Olive mill wastewater (OMWW) is a highly polluting effluent characterized by high concentrations of phenolic compounds, organic load, and color, which pose severe environmental challenges. Although electrocoagulation (EC) effectively reduces a large portion of these contaminants, the treated effluent still contains residual phenolics and dissolved organics that limit its reuse potential. In this study, a hybrid process combining electrocoagulation with activated carbon (AC) adsorption was developed to achieve deeper purification of pretreated OMWW. The EC process was first optimized using aluminum electrodes under neutral pH and a current of 2 A for 60 minutes. Subsequently, batch adsorption experiments were conducted using olive stone-derived activated carbon, and the influence of pH, adsorbent dose, phenolic concentration, and ionic strength was analyzed through Response Surface Methodology (RSM). Results showed that the coupled EC-AC process achieved up to 98% removal of phenolic compounds and 97% reduction of chemical oxygen demand (COD), outperforming either process used individually. The adsorption equilibrium followed the Langmuir isotherm ($R^2 = 0.96$) with a maximum capacity of 1.76 mg g^{-1} , while the kinetics were best described by the pseudo-second-order model. With low energy consumption ($\approx 1.1 \text{ kWh m}^{-3}$) and minimal sludge generation, the EC-AC coupling represents a sustainable, cost-effective, and scalable treatment option for olive mill wastewater management in Mediterranean regions.

Keywords: Electrocoagulation; Activated carbon; Olive mill wastewater; Phenolic compounds; Hybrid process; Response Surface Methodology (RSM); Adsorption isotherms; Pseudo-second-order kinetics; Sustainable treatment

Photocatalytic degradation of Rhodamine B using SnO₂ nanoparticles synthesized with various surfactants

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Abstract

This study investigates the photocatalytic degradation of Rhodamine B (RhB) using SnO₂ nanoparticles as a semiconductor photocatalyst. SnO₂ nanoparticles were synthesized via a modified sol-gel method employing SnCl₂ as a precursor and various surfactants, including the cationic surfactant cetyltrimethylammonium bromide (CTAB), the nonionic triblock copolymer Pluronic F127, and the zwitterionic surfactant sulfobetaine (C₄H₈O₂S). The structural, morphological, and optical properties of the prepared SnO₂ nanoparticles were systematically characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM), Raman spectroscopy, UV-visible spectroscopy, and photoluminescence (PL) analysis. The effects of surfactant type and catalyst loading on photocatalytic performance were comprehensively evaluated. Among the synthesized samples, SnO₂ prepared in the presence of sulfobetaine (SS) exhibited the highest photocatalytic activity, achieving a RhB degradation efficiency of 94% under UV irradiation. These findings emphasize the significant influence of surfactant selection on tailoring the photocatalytic properties of SnO₂ nanoparticles.

Keywords: SnO₂; CTAB; Pluronic F127; modified sol-gel method; Rhodamine B

From used membranes to hydrophobic membranes

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Abstract

In a global context characterized by increasing water scarcity and the accumulation of plastic waste, the valorization of recycled polymers for the fabrication of hydrophobic membranes represents a sustainable and promising approach. This study focuses on the preparation of hydrophobic membranes for desalination applications using recycled polymers and spacers recovered from spent membranes, which are often discarded into the environment in large quantities. Mechanical and chemical treatment processes were combined to convert recycled materials into functional membrane structures with suitable hydrophobic surface properties for water–salt separation. The membranes were characterized using scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), contact angle measurements, and permeation flux tests. The results indicate that the incorporation of recycled components does not negatively affect membrane performance, while significantly reducing the environmental footprint. This circular strategy extends the service life of polymeric materials and contributes to environmental protection in the water treatment sector.

Keywords: polymer recycling, hydrophobic membranes, desalination, circular economy, used membranes.

Impact of treated wastewater reuse on the physico-chemical and microbiological quality of a cultivated plot in an arid zone: Case of the Wadi Chirka-Bechima irrigated perimeter, Gabes, Tunisia.

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Abstract

Due to population growth, climate change, intensive agriculture, urbanization, increased tourism, and geographical constraints, water resources are becoming scarce in many parts of the world, particularly in arid and semi-arid regions. The main objective of reusing treated wastewater for agricultural irrigation was to balance water supply and demand. However, studies of different types of wastewater and soils are needed before these results can be generalized, because changes in microbial community are also considerably influenced by soil type and certain agricultural practices. To evaluate the chronic soil contamination and the cumulative impact of wastewater, we have to do soil analysis of the region of Wadi Chirka, Bechima-Gabes which has been irrigated for fifteen years with treated wastewater (secondary effluent). since its inception, no analysis of soils irrigated with treated wastewater has been published, so our job is to sample in different areas of this irrigated perimeter, during different seasons and at different depths in this soil to subsequently perform analyzes of the different physicochemical and microbiological parameters. four small plots were chosen P1: Plot not irrigated by wastewater P2: Plot irrigated by wastewater for one-year P3: Plot irrigated by wastewater for 7 years P4: Plot irrigated by wastewater for 15 years in these different plots we sampled at 3 different depths, 0-20cm, 20-40cm and 40-60cm. By this work, we will be able to characterize these soils and even predict their future compositions. this study will also allow us to study the mobility of pollutants in the soil and their fate after infiltration. a field study and a comparison with other sites seems necessary.

Keywords: wastewater, soil, physico-chemistry, microbial communities, sustainable agricultural practices.

Reverse osmosis membranes efficiency analysis

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Abstract

Reverse osmosis desalination is an efficient and easy-to-implement separation technique, but complex to develop. Its efficiency is significantly reduced by fouling, a phenomenon that is difficult to limit and complex to describe.

Understanding the factors influencing fouling remains essential for developing strategies to counteract this phenomenon.

This work falls within this framework. It focuses on:

- Characterizing the process efficiency for producing water of a quality that meets physicochemical and bacteriological standards, through the evaluation of a continuous reverse osmosis system.
- Studying the fouling phenomenon by observing variations in flow rate and operating pressure over time.
- The impact of fouling on membrane permeability and selectivity: To evaluate the various resistances associated with fouling, a mathematical model based on the dependence of flow rate on effective pressure was used.

Keywords: reverse osmosis, fouling phenomenon, efficiency.

Advanced PIM-Based Strategies for the Sustainable Recovery of Rare Earth Lanthanum (III) Ions

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Abstract

This study systematically investigates the transport and recovery of lanthanum(III) ions from aqueous media using polymer inclusion membranes (PIMs). The membranes were fabricated with cellulose acetate as the polymeric matrix and a selective ion carrier to facilitate the targeted transport of La³⁺ ions. Critical operational parameters—including feed and receiving phase concentrations, source phase pH, and membrane composition—were rigorously optimized to maximize transport efficiency. Experimental results indicate that La³⁺ flux through the PIM is highly dependent on both solution chemistry and membrane physicochemical properties. Mechanistic analysis suggests that transport is primarily governed by ion-exchange and/or complexation processes between La³⁺ ions and the membrane-bound carrier. These findings demonstrate the robust potential of PIM-based systems for the selective separation and recovery of rare earth elements, with significant implications for industrial wastewater treatment and resource recovery applications

Keywords: Polymer Inclusion Membranes, Lanthanum (III) Recovery, Rare Earth Elements, Ion-Selective Transport

Advanced Membrane-Based Electromembrane Technology for Sustainable Cadmium (II) Recovery from Wastewater

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Abstract

This study introduces an innovative and environmentally friendly approach for the recovery of cadmium (II) ions from aqueous solutions using advanced polymer inclusion membrane (PIM) systems coupled with electromembrane extraction (EME). The membranes were fabricated using cellulose acetate as a sustainable polymer matrix, methyltrioctylammonium chloride (Aliquat 336) as an efficient ion carrier, and nitrophenyl octyl ether (NPOE) as a plasticizer. The influence of critical operating parameters, including feed and receiving phase concentrations, feed solution pH, and applied voltage, was systematically optimized to maximize cadmium transport performance. The results demonstrate that the application of an electric field significantly enhances cadmium recovery, leading to faster transport kinetics and higher extraction efficiency compared to conventional PIM extraction, while the PIM system maintains good membrane stability and selectivity. Overall, this work highlights the strong potential of electromembrane-assisted PIMs as a high-performance and sustainable technology for the efficient removal and recovery of cadmium (II) from contaminated water, contributing to the development of sustainable strategies for wastewater treatment and industrial effluent management.

Keywords: Polymer inclusion membrane, EME, Cadmium recovery, Wastewater treatment.

Advancing Sustainability in Vegetable Oil Refining: Dual-Benefit Water Treatment and Resource Recovery via Membrane Separation

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Abstract

The refining of crude vegetable oils is a water-intensive process that generates substantial volumes of wastewater, primarily from the degumming, neutralization, de-acidification, and deodorization steps. Due to its high organic load and recalcitrant compounds, Vegetable Oil Refinery Wastewater (VORW) poses significant environmental risks if inadequately treated. The presence of oil in VORW limits the effectiveness of conventional treatment methods, as it can induce pipe clogging and impair biomass retention during biological processes. Therefore, it is highly essential to separate the oily component before being released into the environment. Membrane-based technologies are recognized as highly effective separation processes, as they not only enable the production of high-purity water but also facilitate the recovery of valuable by-products. These recovered compounds can be reintegrated into the same process or redirected to alternative industrial applications, thereby enhancing resource efficiency and promoting overall process sustainability.

In this context, the treatment of VORW was investigated using a commercial silicon carbide (SiC) microfiltration (MF) membrane (Liqtech, France) with a pore size of 0.2 μm , operated under cross-flow mode. The treatment yielded promising results, using MF membrane achieving high retention efficiencies of 98%, 97.35%, and 83% for turbidity, chemical oxygen demand (COD), and total organic carbon (TOC), respectively. In addition, water permeability remained essentially stable at approximately 50 $\text{L}\cdot\text{h}^{-1}\cdot\text{m}^{-2}\cdot\text{bar}^{-1}$ across varying volumetric concentration ratios (VCR). Analysis of the oil recovered in the MF retentate showed that the relative distribution of the five major fatty acids was fully preserved, demonstrating that cross-flow microfiltration efficiently separates oil from water without altering its intrinsic composition or quality. Overall, this study demonstrates that MF not only produces water suitable for reuse but also enables the recovery

of high-value lipid fractions, highlighting its industrial potential as a scalable solution for wastewater treatment and vegetable oil valorisation in refining processes.

Keywords: Oily effluent treatment, Membrane separation technology, Oil-water separation, Fat and oil recovery, water purification.

Green Recovery: Membrane-Led removal of Phytotoxicity for Sustainable Soybean Oil Wastewater Reuse

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Abstract

Vegetable oil refining generates highly hazardous wastewater, notably from soybean processing (SEORW), which is often released with inadequate treatment, causing significant environmental risks.

Given its alkaline pH and high concentrations of COD, BOD, with high dissolved solids and oil content, this effluent, requires intensive treatment to meet regulatory standards. To prevent contamination of inland surface waters and ensure safe land disposal, effluent must be rigorously treated to meet regulatory discharge standards set by environmental authorities. While membrane technologies efficiently remove contaminants from aquatic solutions, treated SEORW can still pose environmental toxicity risks. Consequently, relying solely on physicochemical indicators is insufficient; performing specialized toxicity assays is essential to accurately assess the ecological impact and safety of the treated wastewater. Plant bio-indicator tests offer a sensitive, affordable, and effective method for evaluating environmental sample toxicity, comparable to mammalian cell assays. This study leverages these phytotoxicity tests to highlight that membrane treatment of Tunisian SEORW enables safe, sustainable, and eco-friendly reuse for irrigation purposes.

To evaluate membrane performance, filtration experiments were performed using two complementary setups ; cross-flow filtration was conducted with a 0.2 μm silicon carbide (SiC) membrane (0.33 m² active area, Liqtech, France), while dead-end experiments were carried out in an Amicon stirring cell. Experiments involved several flat-sheet membranes, specifically 0.1 μm microfiltration (MF) grades and ultrafiltration (UF) options with molecular weight cut-offs (MWCO) ranged between 10 and 100 kDa. Seed germination assays were conducted using lettuce (*Lactuca sativa*) seeds exposed to distilled water, raw SEORW, and treated SEORW through MF/MF and MF/UF processes. For each treatment, 20 seeds were equidistantly scattered in

sterilized plastic Petri dishes lined with a Whatman filter paper, onto which the respective water samples had been pipetted. The samples were then incubated at 25°C for a duration of seven days to monitor germination.

The samples were incubated at 25°C for seven days to monitor germination, after which the number of germinated seeds and root lengths were recorded to determine the Germination Index (GI).

While the application of cross-flow MF alone resulted in a germination index of 60%, the integration of an additional 0.1- μ m dead-end MF step (MF/MF) substantially improved the treatment performance, raising the germination index to 80%. Treatment efficiency was further enhanced by coupling MF with UF (MF/UF), which completely eliminated the phytotoxicity of SEORW and achieved a 100% GI for all tested MWCOS. Thus, MF/UF-treated water is safe for irrigation use.

Keywords: Ultrafiltration, Microfiltration, Soybean Edible Oil Refinery Wastewater, Phytotoxicity, *Lactuca sativa*.

Microbial metagenomics diversity shifts from one to two stages digesters for enhanced methane production yield

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Abstract

This study aims to compare the microbial associations' structures and functions during anaerobic digestion of fruit and vegetable waste (FVW) for green energy recovery in a single-stage (R₁) and a two-stage (R₂) reactors. Microbial community analysis was investigated employing the Illumina MiSeq sequencing technique. The R₂ achieved a methane yield of 24.8% higher than the R₁, which was a result of a clear difference of anaerobic bacteria and methanogens proliferation in reactors. *Clostridium chartatabidum* and *Lactococcus raffinolactis* bacteria association dominated the dark fermentation (R₂-1) sludge, which favours the cross-feeding lactate pathway producing high acetate concentration. In fact, high levels of acetate, in the second stage methanogenic reactor (R₂-2) feeding promote the development of symbiotic association between syntrophic acetogens (*Syntrophomonas zehnder*) and hydrogenotrophic methanogens (*Methanospaera* spp). Results indicated that FVW contents (carbohydrates and sugars monomers) and pH control are the determinant factors affecting archaeal community shift from acetoclastic methanogens (*Methanotherix soehngenii*) in R₁ to hydrogenotrophic methanogens in R₂-2. In addition, the two-stage configuration promotes a more structured microbial community and enhances methane production.

Keywords: Anaerobic microbial associations, Dark fermentation, Two-stage reactors, Fruit and vegetable waste, Green energy recovery.

Valorization of poultry waste for the production of a natural biosorbent for industrial effluent treatment: a sustainable approach for a future industrial project

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Abstract

Industrial effluents contain mixtures of organic pollutants and other dissolved substances, whose removal can be expensive. This work is part of a future project that aims to transform poultry waste, mainly eggshells produced by agro-industry, into a natural biosorbent. This biosorbent can be used to treat colored water and wastewater from industrial discharges.

Eggshells represent an abundant and underexploited waste material, and their high CaCO₃ content provides interesting properties for water depollution. Motivated by encouraging preliminary trials, we collected a wastewater sample from Oum El Ghellaz lake (Telilat, Oran), a site known for industrial pollution incidents affecting the region. The objective was to evaluate whether simple eggshell-based filtration could improve the basic physico-chemical quality of this polluted water prior to future adsorption studies.

A filtration test was carried out using 30g of eggshell powder. After treatment, the water showed notable improvement; Color and turbidity decreased from 43.386 to 16.312mg/L, and from 55.3 to 1.17NTU respectively, demonstrating a strong clarification effect. The pH increased to 8.39, while conductivity remained stable at 23.7mS/cm, indicating improved clarity without significant changes to the mineral load.

These results highlight the potential of eggshell waste as a low-cost and environmentally friendly material for industrial water treatment. The approach is simple, scalable, and represents a solid basis for treatment of our wastewater in industrial effluents.

Keywords: Industrial effluents, eggshell, natural biosorbent, wastewater, filtration.

Climate change and food security: water and energy strategies for sustainable broiler production

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Abstract

In Algeria, broiler chicken production is experiencing sustained growth to meet exponential demand for white meat, reaching an average of 15kg per capita per year. However, to meet this demand, the sector faces numerous constraints, particularly environmental ones, exacerbated by climate change, which is leading to water scarcity, and high energy costs. According to some studies, 1kg of chicken requires an average of 3 to 4 liters of water for drinking, and when the virtual water contained in feed is included, consumption can reach 1200 to 1500 liters per kg, which is a major challenge in the country's semi-arid areas. In terms of energy, Algerian farms mainly use electricity and gas for heating and ventilation, with average consumption reaching 12 to 15 kWh per kg of meat produced, representing a significant portion of farming costs.

To address these issues, strategies to rationalize water and energy resources should be adopted to ensure sustainable production. With regard to water, this involves optimizing watering systems with low-flow devices to limit waste, monitoring water requirements according to the age and weight of the chickens in order to adjust distribution and avoid excesses, and promoting feed that is less water-intensive, for example by choosing cereals adapted to the local climate. For energy, rationalization can be achieved through better insulated buildings, reducing heat loss, LED lighting and optimized ventilation, and the use of renewable sources such as solar or biomass from poultry waste, reducing consumption by 10 to 20% and CO₂ emissions.

The integration of these approaches, combined with optimized feed and waste management, would make broiler chicken farming sustainable in Algeria. This would not only limit the environmental impact, but also improve economic competitiveness and ensure a regular supply of meat, while addressing climate challenges and local resource constraints.

Keywords: Climate change, food security, water resources, energy efficiency, sustainability.

Reducing the ecological footprint of egg production: innovative approaches to water, energy, and sustainability.

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Abstract

Egg production is an essential pillar of food security in Algeria, ensuring an average annual production of 150 eggs per capita. This production is based on an intensive model, concentrating a large number of animals in relatively small areas. However, this intensification is gradually reaching its limits, as laying hen farming generates significant environmental impacts related to the intensive use of water, energy, feed, and waste management. In this regard, in order to produce 1kg of eggs, an average of 3 to 4 liters of water is needed for drinking, which can reach up to 1000 liters when considering the water contained in feed. For their part, the energy requirements for lighting, ventilation, and heating reach 10 to 12kWh per kg of eggs produced, which contributes to the carbon footprint of farms and increases production costs.

Faced with these challenges, the sustainability of the activity becomes imperative. Integrated approaches could be recommended. In terms of water management, adopting economical watering systems and adjusting the supply according to the age and laying cycle of the hens, rationalizing energy consumption by improving building insulation, installing LED lighting and low-consumption fans. In terms of sustainable feed and waste recovery, formulating rations that reduce virtual water and greenhouse gas emissions, as well as recovering manure as fertilizer to limit pollution and generate additional income.

Combining these strategies would reduce the overall environmental impact, optimize economic performance, and ensure a stable supply of eggs, while taking into account climate constraints and limited local resources. Finally, sustainable egg-laying hen farming would thus be an effective way to reconcile productivity and environmental protection.

Keywords: Ecological footprint, laying hen farming, water management, energy efficiency, sustainability.

Solar photocatalytic degradation of organic dyes using tin sulfide nanoparticles for sustainable water treatment

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Abstract

Tin sulfide nanoparticles were synthesized via a sol-gel method using SnCl₂, with thiourea or Na₂S as sulfur precursors. Comprehensive physicochemical characterization was conducted to elucidate the influence of the sulfur source on phase composition, structural features, surface properties, and photocatalytic performance. XRD analysis revealed that thiourea promoted the formation of hexagonal SnS₂ (11 nm), whereas Na₂S favored orthorhombic SnS (24 nm), highlighting precursor-controlled phase selectivity. SEM observations confirmed distinct morphologies, while optical studies indicated band gap energies of 1.74 eV (SnS₂) and 1.60 eV (SnS). Zeta potential measurements demonstrated contrasting surface charges (-17.4 mV for SnS₂; +9.8 mV for SnS), influencing adsorption and catalytic behavior.

Special emphasis was placed on photocatalytic application for the efficient elimination of organic dye pollutants under solar irradiation. SnS₂ achieved 84% degradation of Rhodamine B, whereas SnS reached 92% degradation of Eriochrome Black T, confirming their high activity toward organic contaminant removal. Overall, this study highlights a simple and effective strategy to tailor tin sulfide nanomaterials for advanced photocatalytic systems, offering promising prospects for sustainable wastewater treatment and environmental remediation technology

Keywords: Tin sulfide nanoparticles, Sol-Gel, Solar Photocatalysis, Organic dye degradation, Wastewater treatment.

Fabrication and characterization of a new ceramic membrane from Tunisian clay: Application to industrial wastewater treatment

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Abstract

In wastewater treatment, the application of ceramic membranes has gained significant attention due to their potential for highly effective filtration. These membranes are typically produced using methods such as spin coating, dip-coating, and spray coating. This research demonstrates the effective treatment of wastewater using cost-effective porous ceramic membranes. The corresponding support was prepared by a Pressing method using Tunisian clay alone followed by the addition of a magnesium carbonate additive to improve certain parameters crucial to filtration sintering from 950 to 1100 °C. The choice of this basic material is justified by its very low cost and its abundance in our country. Various analytical techniques, including XRD and MEB were used to investigate the properties of these ceramic membranes. In addition, the influence of sintering temperature and $MgCO_3$ concentration on the support properties such as porosity and mechanical strength was examined. Our additive significantly enhances open porosity, reaching maximum of 52.6%. The average pore size was determined to be approximately 0,7 μm , making This membranes selected for microfiltration of domestic wastewater.

Keywords: Clay, Ceramic membrane, Pressing method, microfiltration, Wastewater

Experimental and Modeling Study of Airflow and Psychrometry Effects on Cooling Pad Performance

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Abstract

This study presents a combined experimental and modeling investigation of cellulose-based evaporative cooling pads, focusing on the synergistic effects of inlet air psychrometric conditions and air velocity on cooling performance. Experiments were conducted under controlled variations of dry-bulb temperature, relative humidity, water temperature, air velocity, and water flow rate to systematically analyze the interactions among these parameters and their impact on both air cooling and humidification. Results indicate that maximum cooling efficiency (90–95%) is achieved under moderate air temperatures (30–35 °C), low-to-medium relative humidity (30–50%), and moderate airflow, where sensible and latent heat transfers are optimally coupled. Air velocity enhances mass transfer by renewing the air boundary layer, while favorable psychrometric conditions drive efficient evaporation. A one-dimensional heat and mass transfer model was developed and validated against experimental data, accurately predicting outlet air temperatures (MAE < 1 °C) and cooling efficiency (MAE < 7%), demonstrating reliable performance across a wide range of operating conditions. Overall, these findings underscore the critical importance of **coordinated optimization of air psychrometry and airflow** for designing and operating high-efficiency evaporative cooling systems, providing practical guidance for applications in hot and dry climates.

Keywords: Evaporative cooling, Cellulose pads, Air psychrometry, Heat and mass transfer, cooling efficiency.

Sustainable reuse of treated wastewater for irrigation: impacts on soil properties and shallow groundwater quality

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Abstract

The use of treated wastewater (TWW) for irrigation is a crucial strategy to mitigate water scarcity in arid regions. However, the long-term effects of this practice on soil health and groundwater quality remain insufficiently documented, particularly in semi-arid coastal environments. This study aims to assess the dynamics of soil physico-chemical properties and shallow groundwater quality under TWW irrigation in the Thyna region (Sfax–Agareb, eastern Tunisia). Two representative soils of the area were investigated: a Calcisol and a Fluvisol, irrigated with TWW for different durations (2, 4, 16, and 27 years) and compared with non-irrigated control soils. In addition, 21 wells located inside and outside the irrigated zone were sampled to evaluate the response of the underlying coastal aquifer.

The analyzed TWW showed high salinity (class C4S2) and a high residual sodium carbonate (RSC = 3.4 meq/L), indicating a significant risk of salinization and sodification with prolonged use. Although their nutrient content provides a fertilizing potential, the presence of metals (Cr = 1.45 mg/L) and the recent increase in COD highlight potential contamination risks. The soils exhibited contrasting responses depending on their texture and irrigation duration. In the Calcisol, irrigation duration induced opposite geochemical trends: over the long term (27 years), alkalinization (pH +0.33) and CaCO₃ accumulation (+27%) suggest sodification, while over the medium term (16 years), acidification (pH -0.54) and CaCO₃ dissolution (-48%) indicate salinization without sodification. The Fluvisol showed an immediate and pronounced response, with a very rapid salinization (electrical conductivity +2,065% in 16 years) and a gradual acidification (pH -1.09). These geochemical alterations promoted differential metal enrichment over time: early accumulation of zinc, followed in the long term by nickel and iron, contrasting with the more uniform enrichment observed in the Calcisol. A recent recharge of the shallow aquifer by TWW was confirmed by geochemical and isotopic analyses ($\delta^{2}\text{H}$, $\delta^{18}\text{O}$, ^3H). This recharge was evidenced by the presence of tritium (>1 TU), enrichment in stable isotopes, high salinity (3,786–7,340 mg/L), nitrate concentrations >175 mg/L, and trace metal levels (Cr: 0.51–

1.83 mg/L; Pb: 0.126 mg/L) that occasionally exceed drinking water standards.

These findings emphasize the dual role of TWW as both an essential alternative water resource and a potential source of soil and groundwater degradation. The sustainability of this practice relies on an integrated management approach, combining improved wastewater treatment, sound agricultural practices, and isotopic monitoring of the soil–aquifer system. This study provides a solid scientific basis for developing sustainable water management strategies in arid regions, where every drop of irrigation water counts in the face of future climate change impacts.

Keywords: arid region, treated wastewater irrigation, Calcisol, Fluvisol, salinization, sodification, groundwater contamination, isotopic tracers.

Chemical downcycling of retired RO membranes for nanofiltration and ultrafiltration applications

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Abstract

Reverse osmosis (RO) membranes inevitably reach the end of their useful life (EoL). The condition of an EoL RO membrane is influenced by its operational history, including feedwater composition, operating conditions, membrane type, and the predominant degradation mechanisms. In particular, membranes typically discarded because of severe fouling and significant flux decline without mechanical damage require a management strategy that enables maximum value recovery and sustainable reintegration into the water treatment cycle. The downcycling of EoL RO membranes for use in NF/UF processes represents a potentially sustainable and economically viable strategy. This study proposes an oxidative conversion method to repurpose EoL RO membranes for NF/UF applications. Sodium hypochlorite was tested as the chemical oxidant at exposure doses ranging from 2000 to 10000 ppm.h. The effect of exposure dose on membrane surface morphology and chemical characteristics (SEM, FTIR), as well as on permeability and salt rejection, was investigated. The results showed a consistent increase in permeability with increasing dose, while the membrane's selectivity for salt rejection declined. The conversion process resulted in an approximately fourfold increase in permeability, rising from 4.4 to 19.4 L.m⁻².h⁻¹.bar⁻¹. However, salt rejection declined substantially, decreasing from over 98% for all tested salts to about 50% for Na₂SO₄ and 22% for MgSO₄, and to below 10% for NaCl and MgCl₂. The resulting membranes were subsequently evaluated for their potential application in UF processes.

Keywords: RO membrane, Polyamide oxidation, Resource recovery, Reuse.

Advancing Wastewater Treatment: Electrocoagulation as a Rapid and Eco-Friendly Solution for Dye Removal

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Abstract

The removal of dyes from industrial wastewater remains a major environmental challenge due to their chemical stability and ecological toxicity. This study systematically investigates electrocoagulation as an efficient and environmentally friendly technique for the removal of methyl orange (MO), used as a model dye. Experiments were conducted using metallic electrodes to evaluate the influence of critical operational parameters, including initial solution pH, current density, treatment time, and initial dye concentration, on removal efficiency. The results show that electrocoagulation achieves rapid and substantial MO removal, with optimal performance observed at specific pH levels. Notably, solution pH was found to strongly influence the molecular form of MO, affecting its charge, aggregation behavior, and interaction with in situ generated metallic hydroxides. Mechanistic analysis indicates that dye removal occurs primarily via adsorption and destabilization facilitated by these hydroxides, whose formation and efficiency are pH-dependent. This work demonstrates the high potential of electrocoagulation as a simple, scalable, and sustainable approach for the treatment of dye-containing industrial effluents, providing insights for optimizing operating conditions based on dye chemistry.

Keywords: Electrocoagulation, Methyl Orange Decolorization, Industrial Effluents, pH-Dependent Dye Removal

Bimetallic Ti-Mn loaded ZSM-5 zeolites for Catalytic oxidation of VOCs at low-temperatures

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Abstract

Due to the worsening air pollution phenomenon, improving catalysts with low-temperature catalytic properties for the removal of VOCs is crucial for air purification. In this study, Ti and Mn metal-modified Zeolite Socony Mobil-5 (Ti-Mn_x/ZSM-5; where x=0, 0.1, 0.2, 0.3, 0.4, and 0.5) were elaborated via a two-step procedure. Among the elaborated catalysts, the Ti-Mn_{0.2}/ZSM-5 catalyst revealed a micro/meso-porous-structure characterized by abundant oxygen vacancies (OV), high density of acidic-sites, and various active oxygen species, demonstrating superior catalytic-oxidation activity for toluene removal at low-temperatures. The Ti-Mn_{0.2}/ZSM-5 catalyst achieved approximately 100% VOC conversion at 160°C and a GHSV of 15,000mL/(g·h). The greater catalytic performance for VOCs removal may increase from the synergistic-effect between the Mn and Ti. Furthermore, the Ti-Mn_{0.2}/ZSM-5 exhibited significant resistance to moisture, maintaining high stability in both wet and dry environments for over 40h, as well as exhibiting recyclable catalytic properties across eight cyclic tests. The oxidation-mechanism of toluene on Ti-Mn_{0.2}/ZSM-5 catalysts was proposed, which indicated that toluene is oxidized to benzyl-alcohol, benzaldehyde, benzoic-acid, formates, and/or acetate as byproducts, before being eventually transformed to CO₂ and H₂O. As a result, the Ti-Mn_{0.2}/ZSM5 catalysts potential for the oxidation of several types of VOCs, such as acetone, o-xylene, benzene, and toluene was also studied. This study revealed the broad applicability of the Ti-Mn_{0.2}/ZSM5 catalyst and proved its auspicious potential for VOCs removal.

Keywords: ZSM-5 zeolites; Ti-Mn/ZSM-5; Catalytic performance; Toluene; Stability.

Enhancement of the structural and optical properties of ZnO nanosheets through the incorporation of W cations for organic compound degradation.

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Abstract

In this study, novel ZnO/ZnWO₄ nanocomposites were synthesized by a two-step process. ZnO nanoparticles were first prepared by precipitation method coupled, and the resulting materials was impregnated by a tungsten chloride solution followed by calcination in air to form ZnO/ZnWO₄ nanocomposites. The obtained nanocomposites were noted Zn-ZnW_{0.05} ((1)ZnO/ZnWO₄) and Zn-ZnW_{0.2} ((2)ZnO/ZnWO₄), which are contained a 5 and 20 wt% tungsten chloride, respectively. The obtained ZnO/ZnWO₄ materials were characterized by various methods. Their morphology and composition were studied by *transmission electron microscopy*, energy-dispersive X-ray spectroscopy, and *scanning electron microscopy*. According to optical studies, the absorption edge of ZnO nanomaterials revealed that the red-shift with augmented tungsten concentration resulted in a decrease in the forbidden gap energy (E_g) from 3.25 eV to 2.95 eV. In addition, the photochemical properties of semiconductor materials were studied by photoluminescence (PL) analysis. The presence of surface hydroxyl groups was confirmed by X-ray photoelectron spectroscopy, and these hydroxyl groups play a significant role in the photocatalytic activity of the compounds by catching the formed holes in the valence band under irradiation to create the hydroxyl radical, thus improving the photocatalytic property. Zn-ZnW_{0.2} showed the best photodegradation of rhodamine B (RhB). The results showed that the carrier recombination rate of the Zn-ZnW_{0.2} heterostructure decreased compared with those of ZnO and ZnWO₄, indicating an inhibition of radiative recombination which is consistent with an enhanced separation of electron-hole pairs due to the heterojunction.

Keywords: ZnO/ZnWO₄ nanocomposites; Zinc oxide; Tungsten; gap energy (E_g); photodegradation.

MOF-based magnetic catalyst for sustainable electro-Fenton removal of antibiotics

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Abstract

In this study, novel Fe₃O₄@MOF composites were synthesized using a two-step solvothermal method and applied in a heterogeneous electro-Fenton (HEF) process to remove antibiotics from water. The Fe₃O₄@MOF was exhibited a core-shell structure with magnetic properties, enabling easy separation from aqueous solutions. The composite achieved nearly complete tetracycline (TC) degradation in less than 30 minutes and total mineralization of organic carbon after four hours.

The electro-Fenton process generates H₂O₂ in situ, which is efficiently activated to produce hydroxyl radicals, the dominant reactive species responsible for degrading organic pollutants. Despite the typical challenges such ferric sludge formation and low pH requirements in EF processes, Fe₃O₄@MOF demonstrated excellent stability, maintaining high catalytic performance over 10 cycles and showing strong adaptability in a simulated water matrix.

This study highlights the potential of Fe₃O₄@MOF as a promising, easily separable electrocatalyst for wastewater treatment, offering a simple and effective method for removing contaminants like TC from aqueous environments.

Keywords: Electro-Fenton, Antibiotic removal, MOF-based catalyst, Magnetic Composite, Sustainability.

Desalinated seawater for phosphate processing as a key to maintaining the sustainability of the mountain oases of Tamerza, Chebika, and Mides in southwestern Tunisia

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Abstract

The mountain oases of Tamerza, Chebika, and Mides in southwestern Tunisia rely on perennial springs fed by fossil groundwater from the Continental Intercalaire and Complex Terminal aquifers, including the Miocene Beglia Formation, which support both traditional gravity irrigation and high-value Deglet Nour date production. Since the 1950s, extensive groundwater abstraction for phosphate extraction and washing in the Moularès–Redeyef basin, along with agricultural expansion and climate-driven aridification, has caused a significant decline in piezometric levels, spring discharge, and water quality, accelerating soil salinization, biodiversity loss, and the emergence of new date palm pests. This work argues that a strategic, large-scale shift from fossil groundwater to desalinated seawater for mining and industrial uses is the most effective solution to reduce pressure on the aquifers that supply the oases, thereby preserving natural springs and the ecological services they provide.

Keywords: Oases sustainability, perennial springs, groundwater overexploitation, drying up of springs, reduce pressure on aquifers

Heterogeneous Fenton Degradation of Azo Dyes Using Kaolinite Clay as a Catalyst

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Abstract

Water pollution caused by textile effluents represents a significant environmental concern, largely due to the persistence of synthetic dyes in aquatic systems. In this study, the efficiency of a heterogeneous Fenton process employing natural kaolinite clay as a catalyst was investigated for the degradation of the azo dye “Dark Blue”. The clay was calcined at temperatures ranging from 100 to 1000 °C and characterized using X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and scanning electron microscopy (SEM). The results demonstrate that calcination temperature induces substantial structural transformations of the clay, evolving from kaolinite to metakaolinite and subsequently to mullite, which strongly influences its capacity to release Fe²⁺ ions. Optimal operating conditions were determined as pH = 3, H₂O₂ concentration of 0.0561 g/L, Fe²⁺ concentration of 7.371 mg/L, and a calcination temperature of 800 °C, resulting in a maximum degradation efficiency of 95.29 %. These findings confirm that calcined kaolinite clay constitutes an efficient, low-cost, and environmentally friendly catalyst for textile wastewater treatment through advanced oxidation processes.

Keywords: Advanced Oxidation Processes; Heterogeneous Fenton; Calcined Kaolinite Clay; Dark Blue; Optimization; Degradation

Heterogeneous Photo-Fenton Degradation of 8-Hydroxyquinoline-5-Sulfonic Acid Using magnetic nano-Fe₃O₄-Fe₂O₃/Expanded Perlite composites.

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Abstract

The present study investigates the removal of 8-hydroxyquinoline-5-sulfonic acid (8-HQS), a persistent emerging contaminant frequently detected in industrial effluents, using magnetic nano-Fe₃O₄-Fe₂O₃/expanded perlite (EP) composites. Preliminary adsorption experiments were conducted to evaluate the affinity of the synthesized materials toward 8-HQS. All magnetic nano-Fe₃O₄-Fe₂O₃/EP composites exhibited slightly superior adsorption performance compared to raw EP. A comprehensive comparative study was subsequently carried out to assess different treatment processes, including adsorption, UVC photolysis, chemical oxidation with H₂O₂, and heterogeneous photo-Fenton oxidation, in order to identify the most efficient degradation pathway. Among the investigated materials, the granular Fe₃O₄-Fe₂O₃-EP-0.5 catalyst exhibited the highest activity during the heterogeneous photo-Fenton process, achieving 67.9% degradation within 10 min under optimal operating conditions (pH 11, 30 °C, catalyst dosage of 2.5 mg, and an H₂O₂/8-HQS molar ratio of 20). Furthermore, the catalyst demonstrated notable efficiency under solar irradiation, with removal efficiencies of 60.98% under solar light alone and 59.14% in the presence of H₂O₂ after 10 min. Overall, the magnetic nano-composites, particularly the granular Fe₃O₄-Fe₂O₃-EP-0.5 catalyst, can be considered effective and environmentally friendly materials for the removal of 8-HQS from aqueous systems via the photo-Fenton process.

Keywords: Heterogeneous photo-Fenton, 8-HQS, magnetic nano-composite, Wastewater treatment

Mesoporous activated carbon produced from agro-waste for pharmaceutical pollutant removal: Optimization

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Abstract

This study investigates the adsorption of the antibiotic *Cephalexin* using activated carbon prepared from Tunisian coffee waste, proposing a sustainable and environmentally friendly approach to antibiotic removal from water. Two types of activated carbon were synthesized by chemical activation with phosphoric acid (AAC) and sodium hydroxide (BAC). Optimization of the main operating parameters was carried out using response surface methodology (RSM). Characterization (pH_{ZPC}, BET, FTIR, SEM and EDX) revealed that AAC exhibited superior textural and surface properties compared to BAC. Batch adsorption experiments demonstrated that Cephalexin removal reached 88% with AAC and 70% with BAC under optimal conditions of pH, T°, and time. Adsorption had a maximum adsorption capacity of 57.47 mg/g and was based on the pseudo-second-order kinetic model and Langmuir isotherm.

These findings highlight the potential of converting agricultural residues into efficient adsorbents for the removal of pharmaceutical pollutants. The use of coffee waste as a precursor for activated carbon provides both an environmentally friendly waste valorization pathway and a cost-effective solution for water treatment.

Keywords: Coffee waste. Adsorption. Activated carbon, Cephalexin, Optimization.

Biochar/CuFeS₂ composite for sustainable wastewater treatment

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Abstract

The integration of biochar with natural pyrite has emerged as a promising strategy for enhancing dye degradation through combined adsorption and catalytic processes. In particular, biochar/chalcopyrite (CuFeS₂) composite demonstrated strong catalytic activity in Fenton-like reactions, significantly enhancing the removal of cationic dyes. The influence of solution pH, catalyst dosage, and oxidant concentration was systematically examined, revealing that alkaline conditions favor adsorption and accelerate the redox cycling of iron species. The synergistic interaction between copper and iron further promoted hydroxyl radical generation, leading to effective dye degradation across a broad pH range. Biochar contributed not only to radical production but also to catalyst stability, reusability, and buffering capacity, underscoring its role in sustaining reaction efficiency. Overall, this work highlights the potential of biochar-based composites as robust and versatile catalysts for environmental remediation applications.

Keywords: Biochar, chalcopyrite, Fenton-like process, sustainability.

Bridging Performance and Policy in Wastewater Treatment for Water Security: A Double-Bootstrap DEA of ONAS Facilities

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Abstract

Assessing the performance of public wastewater utilities is crucial for sustainable urban development in Mediterranean countries. In Tunisia, the National Sanitation Office (ONAS) faces increasing pressures from aging infrastructure, limited funding, and the obligation to provide universal, high-quality sanitation services. This study evaluates the technical efficiency of ONAS-operated wastewater treatment plants (WWTPs), while explicitly linking operational performance to governance and managerial determinants. Using the double-bootstrap Data Envelopment Analysis (DEA) approach (Simar & Wilson, 2007), which provide statistical robust efficiency estimates for public utilities, the analysis draws on recent operational data from a representative sample of WWTPs across Tunisia. The model considers three inputs (operational costs, energy consumption, staffing) and three outputs (treated volume, population served, pollutant removal of COD, BOD, TSS). In a second-stage, a truncated regression is employed to examine the influence of governance-related and structural factors, including customer density, management arrangements (public versus public-private partnership), treatment technology, and infrastructure age. By distinguishing inefficiencies attributable to managerial and governance choices from those driven by structural constraints, the study aims to provide evidence-based insights to inform sanitation policy reforms. The findings are expected to enhance transparency, accountability, and resource allocation in Tunisia's public sanitation sector and to offer a transferable analytical framework for performance-oriented governance of wastewater services in comparable Mediterranean contexts.

Keywords: wastewater treatment, technical efficiency, DEA, governance, ONAS

Evaluation, Monitoring, and improvement of drinking waters quality in Tunisia

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Abstract

Tunisia, one of the most arid countries in North Africa, faces severe water scarcity due to rising water demand and declining conventional water resources. This situation has increased bottled water consumption, creating a significant financial burden for households. The crisis is driven by climate-induced droughts, overexploitation of groundwater, and ageing water infrastructure, which deteriorate water quality and availability. As a result, vulnerable populations increasingly rely on unsafe water sources, exposing them to serious waterborne health risks. In this context, monitoring and improving drinking water quality is essential for public health protection. The present study aims to evaluate and monitor drinking water quality in different regions of Tunisia by assessing key physico-chemical parameters, Water Quality Index (WQI), residual chlorine, and the formation of disinfection by-products, in order to verify compliance with Tunisian and international standards. Two types of drinking water were analyzed: Tap water and bulk-sold drinking water, with approximately more than ten samples collected for each category. The results reveal significant regional variability in disinfection efficiency and water mineralization. While pH values generally comply with guideline limits, elevated salinity, hardness, chloride, and sulfate concentrations were observed in several areas, particularly in southern regions, frequently exceeding World Health Organization recommendations. Bulk-sold water was generally compliant with quality standards but requires stronger regulatory control to ensure long-term safety. The study also highlights that the quality of tap water can be significantly improved through simple, low-cost, and easily installed household filtration systems, offering a practical alternative to bottled or bulk water consumption. These findings underline the need for reinforced monitoring programs and locally adapted treatment and post-treatment solutions to improve drinking water quality and protect public health.

Key words: Drinking Water; Quality; Disinfection; Health.

Dual environmental remediation using Tunisian bentonite for surfactant removal and subsequent chromate anion adsorption

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Abstract

This study addresses key challenges in desalination and water treatment processes, particularly the management of contaminated industrial effluents and pretreatment streams. It proposes an innovative dual remediation strategy based on the valorization of Tunisian bentonitic clay within a circular economy framework. In the first stage, the clay is used to remove a cationic surfactant (HDPy⁺), leading to the formation of an organoclay. In the second stage, this surfactant-loaded material is reused for the adsorption of chromate ions Cr(VI), a toxic, carcinogenic, and persistent contaminant known to impair water quality and compromise desalination system performance. Structural and surface modifications induced by surfactant intercalation were investigated using infrared spectroscopy (IR), X-ray diffraction (XRD), UV-Visible spectrophotometry, zeta potential measurements, and particle size analysis. Adsorption isotherms of chromate ions reveal a significant enhancement in removal capacity with increasing degrees of organophilization, demonstrating the direct influence of surfactant loading on the affinity and selectivity toward Cr(VI).

This integrated approach enables the reuse and valorization of surfactant-loaded clay, limits secondary waste generation, and fully complies with green chemistry and circular economy principles. The results highlight the strong potential of Tunisian clays as efficient, low-cost, and sustainable materials for pretreatment and polishing steps in desalination and water treatment applications.

Design and modeling of a solar-assisted Humidification–Dehumidification desalination unit

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Abstract

Humidification–dehumidification (HDH) desalination technology offers a well-suited solution for remote and off-grid areas, where freshwater demand typically ranges from about 1 to 100 m³ per day. This technology can be easily coupled with solar energy systems, as it does not require high operating temperatures for effective operation. The basic HDH cycle comprises a humidifier, a dehumidifier, and a heater, where air serves as the medium to transport water vapor from the humidifier to the dehumidifier. The heater provides the total thermal energy needed by the system to produce a desired quantity of freshwater. The objective of this work is to design and model a solar-assisted humidification–dehumidification (HDH) desalination unit. The design provides an overview of the necessary components for the system, their optimal placement, and the various flows circulating within the unit. In the present study, a detailed heat and mass transfer model was developed for a closed-air, open-water (CAOW) type HDH cycle with water heating. This cycle employs a counter-flow packed-bed humidification column for air humidification and a finned-tube heat exchanger for dehumidification. Using this transport model, the optimal sizes of the humidifier and dehumidifier were determined to achieve the desired thermal performance of the cycle, expressed in terms of the gained output ratio (GOR) and recovery ratio (RR). The parametric analysis shows that, for fixed humidifier and dehumidifier dimensions, there always exist optimal values of the mass flow ratio and feed water temperature at which the cycle's GOR is maximized. It is also concluded that the thermal performance of the system is strongly influenced by the performance of both the dehumidifier and the humidifier.

Keywords: Humidification–dehumidification, design, modeling, optimization.

Food and Agricultural Policies and Food Security in Tunisia: A Meta-Analysis

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Abstract

This paper aims to synthesize the issue of food security in Tunisia and to provide a structured guide to the broader field of food and agricultural policy in the country. It is concerned with a systematic examination of empirical studies related to food security, focusing on the methodologies, analytical tools, and policy perspectives that have shaped this research area over time. By doing so, the study seeks to move the policy debate forward by organizing scattered evidence into a coherent analytical framework. In addition, this paper highlights existing knowledge gaps regarding the policy focus on food security in Tunisia, which require further exploration through quantitative synthesis. To address this need, during this study, we applied meta-analysis after constructing research from well-recognized academic and institutional sources to ensure scientific credibility and accessibility. Following a systematic screening process based on predefined criteria—titles, keywords, abstracts, peer-reviewed articles, and studies focusing on Tunisia—a final set of empirical studies published between 2000 and 2026 is selected for meta-analysis. The results provide important insights into food security as a key public policy issue in Tunisia, particularly in relation to food price stabilization, subsidies, agricultural support policies, and trade measures. This analysis shows that the policies play a central role in shaping food availability, access, and stability. At the same time, this study reveals clear gaps in policy-oriented research, particularly regarding long-term resilience and policy coherence. The novelty of this research lies in the application of meta-analytical tools to a nationally focused policy question. Also, it recommends that future studies place greater emphasis on critical, policy-centered assessments of food security in Tunisia.

Keywords: Food Security, Agricultural and Food Policies, Meta-Analysis, Tunisia, Price Stabilization and Subsidies

Design and Optical Evaluation of BF₂-Modified g-C₃N₄: Experimental Characterization, TD-DFT Insights, and Selective Metal Ion Sensing

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Abstract

The detection of toxic heavy metal ions like Cu²⁺, Co²⁺, and Ni²⁺ in water systems is crucial for environmental monitoring and public health. To address the need for sensitive and selective sensors, this study reports the synthesis of a novel fluorescent material, boron difluoride-functionalized graphitic carbon nitride (g-BF₂), via Lewis acid-base coordination. Characterization confirmed successful BF₂ integration, which enhanced thermal stability by 24% and modified the electronic structure, as evidenced by a narrowed band gap and a fluorescence redshift from 472 to 518 nm. The g-BF₂ material functioned as a dual-mode optical sensor. It exhibits distinct colorimetric responses under visible light (blue for Cu²⁺, red for Co²⁺, green for Ni²⁺) and a collective 'turn-off' fluorescence quenching under UV light for these ions, enabling both identification and detection in aqueous media and achieving low detection limits of 20.8 μM, 25.3 μM, and 35.7 μM, respectively. Benesi-Hildebrand analysis confirmed 1:1 (Cu²⁺/Ni²⁺) and 1:2 (Co²⁺) complexation stoichiometries. These results, supported by TD-DFT calculations, highlight g-BF₂'s strong potential as a practical and efficient sensing platform for the detection of hazardous metal cations in water.

Keywords:

Modified g-C₃N₄; BF₂ moieties; Luminescence; Theoretical calculations; Chemosensor.

Optimizing the Adsorption Process for Efficient OTC Removal from Wastewater using Date Pits and Derived Biochar

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Abstract

This research examines the effectiveness of raw date pits biomass (DP) and its biochar derivative (BDP) in adsorbing and removing antibiotics, specifically oxytetracycline (OTC), from wastewater. The structural, morphological, and elemental compositions of both DP and BDP, were analysed using Fourier transform infrared, (FTIR), spectroscopy, scanning electron microscopy (SEM), and energy dispersive X-ray spectroscopy (EDX). The research emphasises critical parameters such as contact time, initial OTC concentration, and temperature. The effectiveness of DP and BDP in removing oxytetracycline OTC was assessed through batch experiments, revealing maximum adsorption capacities of **51.23 mg g⁻¹** (DP) and **25.63 mg g⁻¹** for BDP, respectively.

Green-Synthesized Synergistic CaO–ZnO Nanomaterials for Efficient Solar-Driven Photocatalysis

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Abstract

The increasing demand for sustainable and eco-friendly materials has driven significant research interest in the valorization of biomass and the development of green synthesis methods for functional materials [1]. In this study, we describe a pathway to ZnO nanoparticles supported on CaO via biomass. *Peganum harmala* leaf aqueous extract was used, as reducing agent, to produce surfaces with controlled defects and bio-functional groups. Several characterization techniques: using X-ray diffraction, electron microscopy, and UV–Vis spectroscopy confirmed high crystallinity, well-defined morphology, and highly functionalized surface.

The synthesized nanomaterials exhibit a band gap energy of approximately 3.00 eV, lower than that of TiO₂, a benchmark material with a strong photocatalytic activity.

These engineered features induce excellent photocatalytic performance, ensuring the degradation of organic pollutants under solar light to nearly 100 % with operational parameters (pH, C_i, and Darkness time) systematically optimized.

By merging green chemistry principles with materials engineering, this approach bypasses hazardous reagents. Moreover, synergy between the two metals modulates surface activity and enhances catalytic performances. Our findings present eco-friendly and high-performing CaO–ZnO nanomaterials, offering significant potential for sustainable environmental remediation and future functional applications.

Keywords: Advanced materials; Nanomaterials; Photocatalysis, Eco-friendly materials

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Integrating Environmental Footprints and Health Outcomes of Dietary Patterns in Tunisia: Advancing the WEF–Health Nexus

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Abstract

Tunisia is facing an unprecedented convergence of severe water scarcity and a rise in non-communicable, chronic, diet-related diseases. However, current research and policy frameworks largely address environmental sustainability and public health in isolation, limiting the capacity to design food systems adapted to the water-stressed Mediterranean context.

This study fills a crucial scientific gap by proposing an integrated Water-Energy-Food-Ecosystems-Health (WEFE-Health) framework to jointly assess the environmental and health implications of dietary habits in Tunisia. The objective is to evaluate how current dietary habits simultaneously contribute to environmental pressures—including water consumption, carbon emissions, and land demand—and to the public health risks associated with chronic nutrition-related diseases.

Representative Tunisian dietary habits are characterized using national food consumption data. Their environmental footprint is estimated using food composition databases, life cycle assessment indicators, and region-specific agricultural parameters. Health implications are explored by linking dietary profiles to established public health indicators, including nutritional imbalances and the risk of non-communicable diseases.

By integrating environmental and health dimensions within a unified analytical framework, this work identifies potential trade-offs and co-benefits between food sustainability and health outcomes. Preliminary results suggest that certain dietary changes could significantly reduce water demand while improving nutritional quality, highlighting opportunities for combined environmental and health improvements.

This research advances the understanding of the water, energy, and environment (WEFE) nexus by explicitly integrating human health as a fundamental outcome of food system sustainability. It provides a transferable framework for evidence-based food strategies in water-scarce regions and contributes to the design of integrated food, health and environment policies in Tunisia and similar Mediterranean contexts.

Keywords: Dietary patterns, Environmental footprint, Public health, WEF–Health nexus, Tunisia.

From Structure to Signal: Optical Tuning of New g-C₃N₄ Schiff Bases for Metal Ion Sensing

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Abstract

This study reports the design of g-C₃N₄-based polymeric chemosensors functionalized with Schiff base derivatives formed by condensing g-C₃N₄ with three structurally distinct aromatic aldehydes. The aim is to explore how aldehyde substituents and conjugation influence the structural, thermal, and optical properties of the resulting materials. FTIR confirmed imine linkage formation, while UV-Vis and fluorescence studies revealed solvent-dependent optical shifts and variable emission intensities. g-Ald-B (hydroxy-naphthalene) and g-Ald-C (pyrene) exhibited strong fluorescence, in contrast to the weakly emissive nitro-substituted g-Ald-A. All derivatives showed selective fluorogenic or colorimetric responses to Zn²⁺, Cu²⁺, Co²⁺, and Ni²⁺ ions. Notably, g-Ald-B displayed the highest affinity for Zn²⁺ ($K_a \approx 6.2 \times 10^4 \text{ M}^{-1}$) and the lowest detection limit (0.06 μM), demonstrating its high sensitivity. These results highlight the potential of structurally tuned Schiff base-modified g-C₃N₄ as versatile and efficient multi-ion sensors.

Keywords: Fluorogenic chemosensors, Conjugation-driven sensing, G-C₃N₄ Schiff bases, Turn-on fluorescence, Multi-ion detection

MXene-Based Composite as an Efficient Catalyst for Photo-Fenton Degradation of Organic Pollutants

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Abstract

Water pollution by organic contaminants is a major environmental challenge. This study focuses on the synthesis of an MXene-based composite and its application for the degradation of an organic pollutant using a photo-Fenton process. Due to their remarkable physicochemical properties, MXenes enhance charge transfer and promote the generation of reactive oxygen species. The results show a significant improvement in pollutant degradation efficiency under light irradiation in the presence of hydrogen peroxide. This innovative material demonstrates strong potential for advanced oxidation processes and sustainable water treatment applications.

Keywords: MXene-based composite; Photo-Fenton process; Organic pollutant degradation; Water treatment

Hydrodynamic Response of Oasis Aquifers to Illegal Groundwater Pumping: Decline and Spatial Migration of Water Tables in Kebili, Southern Tunisia

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Abstract

Unauthorized groundwater extraction in Kebili, Southern Tunisia, has a major negative influence on the hydrodynamic behavior of oasis aquifers, making it difficult to manage water resources sustainably in dry regions. With a focus on measuring water table decline and migratory patterns, this study examines the geographical and temporal reactions of the aquifer systems beneath the Kebili oases to illicit groundwater pumping. We examine how much uncontrolled abstraction upsets the natural balance of these delicate aquifer systems using a combination of field observations, remote sensing data, and hydrogeological models.

With rates of drawdown changing spatially in proportion to pumping intensity and aquifer features, the results show a marked fall in water table levels throughout the region. A progressive change in groundwater flow regimes, resulting in localized depletion zones and elevated hydrodynamic gradients, is indicated by the spatial migration of water tables. These modifications make the oasis ecosystems much more vulnerable, which has an impact on long-term water availability and agricultural output. Continued illicit pumping is expected to cause irreversible harm to the aquifer system, which could result in saline intrusion and deterioration of the water quality, according to hydrogeological models calibrated with observed data.

In order to lessen the negative effects of illicit pumping, the study emphasizes the urgent need for integrated groundwater management measures that include monitoring, regulation, and community engagement. To maintain the ecological and socioeconomic functions of the Kebili oases, effective policy implementation must place a high priority on the preservation of recharge regions and the restoration of natural flow dynamics. This study offers a scientific foundation for well-informed decision-making and sustainable groundwater governance by shedding light on the intricate relationships between human activity and hydrogeological processes in dry places.

Keywords: Groundwater extraction, Water table decline, Oasis aquifers, Sustainable management

Ecotoxicological Effects of Polluted Water on Aquatic Organisms: Environmental and Biological Insights

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Abstract

Water pollution represents one of the most critical environmental challenges affecting freshwater and marine ecosystems worldwide. This study investigates the environmental impact of contaminated water on key ecological indicators, including biodiversity, water quality parameters, and biological responses of sentinel species. Sampling was conducted over 12 months at five representative sites along a gradient of pollution intensity, including urban effluent discharge zones and reference (unpolluted) areas. Physicochemical analyses revealed significant deviations from acceptable environmental standards: mean concentrations of nitrates (12.4 ± 1.8 mg/L) and phosphates (2.8 ± 0.5 mg/L) exceeded regulatory thresholds in polluted zones, while dissolved oxygen levels were reduced (4.1 ± 0.7 mg/L) compared to reference sites (7.8 ± 0.4 mg/L). Biological assessments showed a notable decline in macroinvertebrate diversity, with the Shannon index dropping from 3.1 in reference sites to 1.7 in heavily impacted areas ($p < 0.01$). Additionally, exposure to polluted water correlated with elevated oxidative stress markers (malondialdehyde increased by 48 %) and histopathological alterations in gill tissues of fish species, indicating sublethal toxic effects. Our results demonstrate that water contamination leads to deteriorated habitat quality, shifts in community structure, and physiological stress in aquatic organisms. These findings highlight the urgent need for integrated water management strategies, improved wastewater treatment, and continuous biomonitoring to protect freshwater biodiversity and ensure ecosystem resilience.

Key words: Water pollution; Aquatic ecosystems; Environmental impact; Biodiversity loss; Oxidative stress; Heavy metals; Histopathology

Ultrasonication-Assisted Biosorption of Cationic Dye from Aqueous Phase

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Abstract

In the present study, the biosorption of cationic dye (BG) from aqueous phase was investigated with and without the assistance of ultrasound. Kinetic biosorption data carried out in batch conditions. The influence of different operating parameters such as ultrasonic power, cationic initial concentration dye, biosorbent mass, temperature, and the combination of ultrasound and mechanical stirring on the kinetics of dye removal was studied. The obtained results show that the ultrasonic irradiation significantly enhances and improves the efficiency of the removal of cationic dye. Ultrasonic power played a key role in the removal of cationic dye. The biosorption kinetic data were found to be well-represented by the pseudo-second-order rate equation, both in the absence and presence of ultrasound. Furthermore, in this work, the biosorbent was characterized by isoelectric potential (pH_{ZPC}) the acidic and basic sites were calculated by the Boehm titration method and by scanning electron microscopy (MEB).

Keywords: Ultrasound; Biosorption; Basic dye, Characterization; Kinetics, Modelling.

Transforming Desalination Efficiency through AI and IT/OT Synergy

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Abstract

Water desalination plants are facing growing pressure from increasing maintenance costs, rising energy prices, intensive chemical consumption, and increasingly strict environmental regulations, all of which directly affect operational efficiency and sustainability. Traditional monitoring and siloed automation systems limit visibility across the process and prevent operators from understanding the true causes of inefficiencies, repeated failures, and premature equipment degradation.

This paper presents how SIOTH® (Smart IoT Highway), powered by the SIOTH AI Engine, provides an end-to-end IT-OT-IoT integration and intelligence framework for desalination facilities. The platform connects field instrumentation, control systems, laboratory measurements, maintenance systems, and enterprise applications into a unified operational data model. By contextualizing both real-time and historical data, SIOTH enables advanced analytics, augmented intelligence, and automated workflows that transform raw plant data into actionable operational knowledge.

Through predictive and prescriptive failure analysis, the platform detects abnormal operating conditions, identifies equipment degradation patterns, and recommends corrective actions before failures occur. This approach extends asset lifecycle, increases plant uptime, reduces unplanned shutdowns, and lowers maintenance costs. The SIOTH AI Engine performs root cause identification across process, mechanical, and operational domains, allowing operators and management to understand not only what is happening but why it is happening and what should be done.

By optimizing membrane performance, chemical dosing, energy usage, and maintenance interventions, the framework delivers measurable reductions in OPEX while improving reliability, operational resilience, and environmental performance across the entire water production lifecycle from intake to distribution.

Keywords: SIOTH AI Engine, Maintenance Cost Reduction & Energy Optimization and Chemical Optimization, Prescriptive Failures & Root Cause Identification and Asset Lifecycle Extension, Augmented Intelligence, Sustainability.

Photocatalytic Degradation of Ciprofloxacin Using a BiFeO₃/TiO₂ Heterostructure with Peroxymonosulfate Activation

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Abstract

The widespread presence of the antibiotic ciprofloxacin (CIP) in aquatic environments poses a significant ecological threat due to its persistence and low biodegradability. This work investigates the enhanced photocatalytic degradation of CIP using a BiFeO₃/TiO₂ heterostructure, activated by peroxymonosulfate (PMS). The BiFeO₃/TiO₂ composite was synthesized via the sol-gel method and its performance was evaluated under both UV and visible light irradiation. The synergistic combination of the heterostructure and PMS resulted in the highly efficient generation of reactive oxygen species, primarily sulfate (SO₄^{•-}) and hydroxyl (OH[•]) radicals, leading to superior CIP degradation. Remarkably, the system demonstrated near-identical degradation efficiency under visible light compared to UV irradiation, highlighting the catalyst's effective utilization of solar energy. Control experiments confirmed the essential role of both light irradiation and the catalyst in the oxidation process. The high performance under visible light underscores the potential of the BiFeO₃/TiO₂/PMS system as a sustainable and energy-efficient advanced oxidation process for the remediation of organic pollutants in water.

Keywords: Photocatalysis, Heterostructure, BiFeO₃/TiO₂, Peroxymonosulfate, Ciprofloxacin, Advanced Oxidation Processes, Water Treatment.

Performance of a Natural Bio-Coagulant Derived from Canary Oak Leaves in Treatment of Natural Waters

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Abstract

Coagulants are used to clarify water by aggregating suspended particles. Since these chemical substances are often synthetic and may have negative environmental impacts, bio-coagulants have gained increasing attention due to their eco-friendly nature and high efficiency. In this work, a bio-coagulant was prepared by grinding Canary Island oak leaves into powder. X-ray diffraction (XRD), scanning electron microscopy (SEM), and Fourier transform infrared (FTIR) spectroscopy were used for the structural and morphological characterization of the prepared bio-coagulant. The application of powdered oak leaves as a bio-coagulant was evaluated through batch coagulation–flocculation experiments using several natural water samples. The experimental results showed that the bio-coagulant was effective in removing turbidity, suspended solids (SS), and various minerals such as calcium, magnesium, and iron, with removal efficiencies reaching up to 90% under optimal conditions. These findings suggest that the proposed bio-coagulant could be used as an alternative to conventional coagulants to improve the overall quality of drinking water.

Keywords: Bio-coagulant, Preparation, Oak leaves, Characterization, Natural water treatment.

Integrated Aquaponics for Sustainable Water Reuse and Food Production: A Case Study from Northeastern Algeria

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Abstract

In the face of limited water resources and increasing pressure on agricultural systems, aquaponics offers a resilient and sustainable alternative for integrated food production. This study explores the potential of aquaponic systems in Algeria through the evaluation of water quality management practices on a multifunctional farm located in Daghoussa village, El Besbes municipality (El Tarf province).

The aquaponic setup combines fish farming with citrus and peach cultivation using a geomembrane-lined pond supplied by groundwater. Red and grey tilapia are reared for human consumption, while nutrient-rich water is reused for crop irrigation. Water quality assessment was conducted using a U-50 HORIBA® multiparameter to evaluate parameters essential for system stability and productivity.

Results indicate stable temperature and near-neutral pH values, while elevated electrical conductivity and salinity levels reflect the mineral content of borehole water. Despite these conditions, Nile tilapia demonstrated adequate tolerance, confirming its suitability for aquaponic systems in semi-arid environments. The findings emphasize the strategic role of aquaponics in enhancing water use efficiency, supporting food security, and promoting environmentally sustainable agriculture in Algeria. Regular monitoring and adaptive management of water quality parameters are essential to ensure long-term system performance.

Keywords: Aquaponics, Sustainable agriculture, Water management, Tilapia, Algeria.

Water Quality Assessment in an Integrated Aquaponic System in Northeastern Algeria

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Abstract

Aquaponics, an integrated system combining aquaculture and agriculture, offers an efficient and sustainable approach to food production through the recycling of water and nutrients. This study aims to assess the quality of water used in an aquaponic system by analyzing key physicochemical parameters relevant to both fish farming and plant irrigation. The investigation was conducted on a mixed-production farm located in the El Malha area, El Kala municipality (northeastern Algeria).

The farm operates two aquaculture basins, one lined with geomembrane and the other constructed of concrete, used for the rearing of tilapia and mullet as well as for the irrigation of citrus crops. Additional agricultural activities include beekeeping, sheep breeding and ornamental bird rearing. Water quality was monitored using a U-50 HORIBA® multiparameter probe, measuring temperature, pH, electrical conductivity, total dissolved solids, salinity and turbidity.

Recorded temperatures ranged from 22.84 ± 0.031 °C to 23.01 ± 0.06 °C, with pH values between 8.39 ± 0.12 and 8.43 ± 0.51 . Total dissolved solids varied from 0.45 ± 0.13 g/L to 0.65 ± 0.001 g/L, salinity from 0.3 to 0.5 ppt, electrical conductivity from 0.71 ± 0.20 to 1.023 ± 0.004 mS/cm, and turbidity from 66.83 ± 9.62 to 177 ± 112.42 NTU. All measured values complied with reference standards for freshwater aquaculture and irrigation water quality. These findings confirm the suitability of aquaponic systems as an environmentally sustainable solution for integrated food production in water-limited regions.

Keywords: Aquaponics, Water quality, Physicochemical parameters, Aquaculture, Algeria.

Environmental Impacts of Water Quality and Availability on Biodiversity Dynamics

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Abstract

Water is a fundamental determinant of biodiversity, shaping the structure, function, and resilience of ecosystems across terrestrial and aquatic environments. However, anthropogenic pressures including pollution, overexploitation, habitat modification, and climate change have significantly altered water quality and availability worldwide. These changes directly and indirectly influence species distribution, population dynamics, genetic diversity, and ecosystem stability. Nutrient enrichment from agricultural runoff often leads to eutrophication, reducing oxygen levels and causing mass mortality of aquatic organisms. Industrial contaminants, heavy metals, and emerging pollutants such as microplastics further threaten freshwater and marine biodiversity by disrupting physiological processes and reproductive success. Additionally, alterations in hydrological regimes through dam construction, groundwater extraction, and wetland drainage fragment habitats and impede migration pathways, reducing species connectivity and resilience. Climate induced shifts in precipitation patterns and rising temperatures intensify these pressures by modifying water chemistry and flow variability, thereby reshaping ecological interactions. Freshwater ecosystems, despite covering a small fraction of the Earth's surface, support disproportionately high biodiversity and are among the most threatened globally. Terrestrial biodiversity is equally affected, as water scarcity influences vegetation composition, soil biota, and trophic networks. Understanding the environmental impacts of water on biodiversity requires integrated approaches that combine hydrology, ecology, and environmental management. Protecting water resources through sustainable watershed management, pollution control, habitat restoration, and adaptive climate strategies is essential for maintaining biodiversity and ecosystem services. Safeguarding water quality and availability is therefore not only an environmental priority but also a cornerstone of long-term ecological sustainability and human wellbeing.

Nanotechnology for water treatment

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Abstract

The quality of freshwater resources is increasingly threatened by industrial effluents, agricultural runoff, and a growing number of emerging pollutants. These contaminants, which include heavy metals, persistent organic compounds, and resistant microorganisms, pose serious risks to ecosystems and human health. However, conventional water treatment methods often struggle to remove such complex and stable pollutants effectively, highlighting the need for more advanced and efficient purification technologies. In recent years, nanotechnology has emerged as an innovative approach to improve water treatment processes. Nanomaterials possess unique properties, including a high surface area, tunable surface chemistry, and strong catalytic activity, which enhance their ability to remove contaminants efficiently. Different types of nanostructured materials, such as metal and metal oxide nanoparticles, carbon-based materials, and polymer nanocomposites, have demonstrated significant potential for water purification applications. These materials contribute to pollutant removal through multiple mechanisms. Nanoadsorbents allow rapid and selective capture of toxic substances, including heavy metals and organic pollutants. Photocatalytic nanomaterials generate reactive oxygen species that break down persistent and resistant organic compounds into less harmful products. In addition, nanostructured membranes improve water permeability and selectivity while reducing membrane fouling, enabling more efficient desalination and effective removal of pathogens and suspended particles. Despite these promising advantages, several challenges limit their largescale application. Issues related to material stability, potential environmental and health risks, high production costs, and difficulties in recovery after use remain important concerns. To address these limitations, current research focuses on ecofriendly synthesis methods, the development of recyclable nanomaterials, and the integration of nanotechnology with conventional treatment techniques in hybrid systems. Overall, nanotechnology represents a powerful and sustainable strategy for enhancing water purification efficiency and supporting long-term water resource management.

Climate change impacts on epigenetics

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Abstract

Climate change is a complex and dynamic process, it is characterized by significant modifications in key environmental factors including warming temperatures, fluctuations in precipitation patterns, air quality, food availability, ocean acidification, increased salinity droughts, and floods. These severe challenges impose substantial ecological constraints, with more than one million species projected to face extinction in the coming decades, if they fail to adapt to changing climatic conditions. Adaptation can arise through both genetic and non-genetic mechanisms. However, organisms are often confronted with environments that change at rates exceeding the capacity of their genomes to adapt through mutation alone. In this context, epigenetic modifications play a critical role by enabling faster responses and rapid phenotypic variability that help organisms cope with drastic climate driven environmental changes. Evidence across diverse taxa including microbes, plants, invertebrates, fish, birds, and mammals, demonstrates that climate related environmental stressors induce epigenetic modifications that drive changes in physiology, development, and phenotypic variation. These epigenetic responses enable organisms to adapt to fluctuating environments by modulating genome activity in response to external conditions. Importantly, climate-induced epigenetic effects are not limited to directly exposed individuals but can also be transmitted to subsequent generations through epigenetic transgenerational inheritance. This inheritance mechanism contributes to both short term acclimation and long-term adaptive processes, linking environmental exposure to evolutionary outcomes. Environmental epigenetics therefore mediates both immediate biological responses and multigenerational consequences of climate change, influencing organismal resilience, adaptation, and survival.

Applicability of electrocoagulation process for the treatment of pharmaceutical industry wastewater

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Abstract

Persistent and emerging organic pollutants, such as pharmaceuticals, are frequently detected in wastewater due to their incomplete removal during usual treatments. Particularly, several works were found that conventional wastewater treatment plants are ineffective in eliminating antibiotics. The spread of these chemicals in the environment may cause toxicity to aquatic organisms and contribute to the contamination of surface water, groundwater, and soils. This promotes the development of antibiotic resistance phenomenon, contributes to long-term ecological disturbances and then poses serious risks to human health.

The present work focuses on the treatment of pharmaceutical industry wastewater as main source of pharmaceutical contaminants. For this, the applicability of electrocoagulation (EC), an advanced electrochemical treatment process, was evaluated as a complementary treatment process. The study started with a deep diagnostic of the industrial water system. The main pollution sources, where the concentration of the drugs residues are the highest, have been identified and the contaminated water was characterized. This diagnostic was followed by a prioritization study of the active pharmaceuticals ingredients (APIs) frequently used in the manufacturing of the medicaments. Four potential APIs were then selected: Amoxicillin (AMX), Paracetamol (PRC), Metformin (MET), and Metronidazole (MTZ).

At lab scale, removal tests were done in a Bach EC reactor using Al- or Fe-electrodes. Experimental variables were the electrolytic solution, current density, inter-electrode distance and treatment time. Results of the preliminary study showed limited removal efficiency for AMX, PRC, and MET, while significantly higher removal performance was observed for MTZ. Subsequently, the experimental parameters were optimized by Response Surface Methodology (RSM).

Keywords: Electrocoagulation, Metronidazole, Pharmaceuticals, pharmaceutical industry wastewater

Low-Energy Dye Removal from Water Using Carbon-Based Adsorbents

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Abstract

This study evaluates the adsorption performance of two low-cost carbon-based materials for dye removal from water: raw banana peel powder and a magnetically separable Fe₃O₄/activated carbon composite. Both adsorbents were tested under identical batch conditions using synthetic dye solutions of Crystal Violet (CV) and DTTO to assess removal efficiency and operational feasibility. Scanning electron microscopy confirmed the porous structure of banana peel and the uniform dispersion of magnetite nanoparticles within the activated carbon matrix. The magnetic composite enabled rapid solid-liquid separation without filtration or centrifugation, reducing energy consumption during treatment. The Fe₃O₄/activated carbon composite demonstrated higher adsorption capacity (70 mg/g for CV) compared to banana peel (54.34 mg/g for DTTO). These results highlight the potential of simple, energy-efficient adsorption technologies for sustainable water treatment in Mediterranean regions.

Keywords: Carbon-based adsorbents, magnetic separation, dye removal, low-energy process,

Sustainable Cationic Dye Removal by Adsorption onto Magnetic and Non-Magnetic Alginate Beads: Comparative Study

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Abstract

The increasing discharge of cationic dyes, particularly methylene blue (MB), from textile and industrial effluents poses significant environmental and health risks, highlighting the urgent need for the development of efficient and sustainable remediation technologies. Therefore, many cost-effective biomass-derived materials have been utilized. However, issues arise with the separation and regeneration of powdered adsorbents, limiting their utility. To enhance their efficiency and value, these powders are transformed into beads through alginate encapsulation. This study presents a comparative investigation of magnetic and non-magnetic alginate beads encapsulating activated biomass for the removal of methylene blue from aqueous solutions. Batch adsorption experiments were conducted to evaluate the effects of key parameters including initial dye concentration, pH, contact time, adsorbent dosage, and temperature on MB removal efficiency. The comparative study revealed distinct differences in adsorption behavior and practical applicability between magnetic and non-magnetic systems. Magnetic alginate beads demonstrated superior potential for industrial applications due to rapid and ease of separation while non-magnetic beads could provide cost-effective alternative for smaller-scale applications. Finally, the findings may contribute to the development of circular economy approaches by valorizing biomass waste into high-performance adsorbent materials.

Keywords: Activated Orange Peels, Alginate, Composite beads, Magnetic beads, circular economy

Modeling of Seawater Falling Film Desalination System integrated with Vapor compression

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Abstract

Falling film evaporation-based desalination represents an efficient solution for freshwater production in regions facing water scarcity. In this work, a numerical investigation of phase-change heat and mass transfer in a seawater falling film subjected to mixed convection of a gas mixture inside a vertical tube is performed. The coupled hydrodynamic, thermal, and species transport equations are solved using a finite difference method. The spatial evolution of the liquid film thickness is predicted, and the numerical results exhibit good agreement with available experimental data.

The analysis reveals that latent heat transfer dominates the evaporation process. Moreover, variations in salt concentration significantly affect the thermophysical properties of the liquid film, leading to noticeable changes in temperature distribution, evaporation rate, and vapor concentration within the tube. The findings provide a detailed understanding of salinity effects on falling film evaporation and offer useful guidance for the design, performance assessment, and optimization of falling film desalination systems.

Keywords: Desalination, Falling Liquid Film, Vertical tube, Evaporation

Developpement of PES based composite membrane incorporated with Bio-Hydroxyapatite: Heavy Metal Removal and antifouling resistance.

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Abstract

Water contamination by heavy metals has become a serious global issue, driven by energy production, mining operations, rapid industrialization, and expanding urbanization [1]. To address this challenge, membranes with adsorption capability have been widely employed for the removal of heavy metals from aqueous media due to their efficiency and operational simplicity [2].

In this study, novel antifouling composite membranes were developed for efficient heavy metal ions rejection from water. PES/bio-ceramic hydroxyapatite (N-HAp) mixed matrix membranes were prepared using TamiSolve NxG as a sustainable solvent via non-solvent induced phase separation (NIPS) technique. The biomaterial N-HAp was added at different concentrations from 0.5 to 3 wt% to ensure enhanced membranes performance. The obtained membranes were then characterized in terms of morphology, thickness, porosity, pore size, contact angle and mechanical resistance. The evaluation of the membrane performance was based on pure water permeability and the retention of copper and iron ions. The results showed that the addition of N-HAp improved the hydrophilic properties of the membranes. The modified membrane exhibited a higher pure water permeability up to 534.64 L/m² h bar respect to the pure PES membrane. High separation efficiency of around 93 % and 64 % for Cu²⁺ and Fe²⁺ ions, respectively, were obtained for the membranes containing N-HAp. A higher FRR value was achieved, reaching 85 % for the modified PES membrane with 1wt% of N-HAP. The findings indicated the viability of N-HAp as a sustainable additive in the fabrication of MMMs.

Keywords: Membrane-based technology, Hydroxyapatite, Antifouling, Heavy metal ion removal.

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Eco-Friendly Bioadsorbent Derived from Agricultural Waste for Efficient Dye Removal

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Abstract

This study investigates the removal of methyl orange, a synthetic azo dye commonly present in industrial wastewater, by adsorption onto lemon peel-based biosorbent. Lemon peels were selected due to their abundance, low cost, and environmentally friendly nature. The biosorbent was prepared and characterized prior to evaluating the effects of key operational parameters, including solution pH, adsorbent dosage, temperature, and initial dye concentration, on the adsorption performance. Process optimization was carried out using Response Surface Methodology (RSM) based on a central composite design. The experimental data were well described by a quadratic model, with a coefficient of determination R^2 of 0.832, confirming the reliability of the model. Adsorption isotherm analysis revealed that the Temkin model best fits the equilibrium data, indicating heterogeneous surface interactions and multilayer adsorption. Kinetic studies demonstrated that the adsorption process follows a pseudo-second-order model, suggesting that chemisorption is the rate-controlling step. Furthermore, thermodynamic analysis confirmed that the adsorption of methyl orange onto lemon peels is spontaneous, exothermic, and predominantly physical in nature.

Keywords: Biosorption, Dye, Agricultural waste, Isotherms, Optimisation.

Gliding Arc Discharge (GAD) Assisted Catalytic Removal of Chlorpheniramine: Application to Pharmaceutical Wastewater Treatment.

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Abstract

Over the years, the production of medicines has significantly increased, resulting in water pollution from pharmaceutical substances. This pollution has harmful effects on the ecological system and living beings. As a result, removing these contaminants from aqueous effluents has become a major concern. The Gliding Arc Discharge (GAD) is an efficient non-thermal plasma technique able to degrade organic compounds dispersed in water at atmospheric pressure due to the high oxidation capacity of the gaseous species like OH[°], H₂O₂ and O₃ present in the humid air plasma. The degradation and mineralisation of an active pharmaceutical ingredient the Chlorpheniramine (CPA) in aqueous solution (10⁻⁴M) was performed by two distinct plasmageneous processes: GAD and GAD/Fe²⁺. Under optimal condition, the degradation of CPA was around 80%. This implies that the majority molecules of CPA are destroyed. In other hand, the hydroxylation reaction of CPA can be treated as a kinetic pseudo-first order. The rate reduction of Chemical Oxygen Demand (COD) was respectively 50% and 65% for GAD and GAD/Fe²⁺ of a wastewater from a pharmaceutical industry contaminated with chlorpheniramine (CPA).

Keywords: Plasma treatment, Glidarc, Chlorpheniramine, pharmaceutical effluent.

Removal of Methyl Green dye by new biocomposite (activated carbon/polyaniline)

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Abstract

The development of industrial activity causes the emission of various toxics effluents in the environment which pose a threat to the ecosystem. Therefore, their elimination has become a priority and constitutes currently a major preoccupation for scientists. In this context, we have focused our research to synthesize the new composite based on conductive polymer and activated carbon locally available source such as *Thymelaea hirsuta* wood THW. We initially started our work by the pretreatment and carbonization of the THW, and then we prepared a conductive composite THW/PANI by the In-situ chemical polymerization method. Subsequently, the composite was applied for the removal of Methyl Green dye (MG) from aqueous solutions. Experimental parameters such as temperature, contact time, initial dye concentration, and adsorbent mass were studied. The equilibrium isotherms were analyzed using the Freundlich and Langmuir models. BET analysis confirmed the presence of a mesoporous structure and found a specific surface area of 10.20 m²/g and a pore diameter of 187.14 Å. Adsorption equilibrium was achieved within 70 minutes, as determined by kinetic analysis. Pseudo-second-order kinetics described MG adsorption. Freundlich modeling showed maximum adsorption capacities of 10.10 mg/g at 70mg/L of MG. The adsorption was spontaneous and exothermic, consistent with thermodynamic parameters. Isothermic heat of adsorption indicated physisorption with weak intermolecular interactions between the dyes and the composite surface.

Keywords: activated carbon, PANI, composite, adsorption, methyl green.

Fabrication and characterization of a new ceramic membrane from Tunisian clay: Application to industrial wastewater treatment

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Abstract

In wastewater treatment, the application of ceramic membranes has gained significant attention due to their potential for highly effective filtration. These membranes are typically produced using methods such as spin coating, dip-coating, and spray coating. This research demonstrates the effective treatment of wastewater using cost-effective porous ceramic membranes. The corresponding support was prepared by a Pressing method using Tunisian clay alone followed by the addition of a magnesium carbonate additive to improve certain parameters crucial to filtration sintering from 950 to 1100 °C. The choice of this basic material is justified by its very low cost and its abundance in our country. Various analytical techniques, including XRD and MEB were used to investigate the properties of these ceramic membranes. In addition, the influence of sintering temperature and $MgCO_3$ concentration on the support properties such as porosity and mechanical strength was examined. Our additive significantly enhances open porosity, reaching maximum of 52.6%. The average pore size was determined to be approximately 0,7 μm , making this membranes selected for microfiltration of domestic wastewater.

Keywords: Clay; Ceramic membrane; Pressing method, microfiltration, Wastewater

AI-Driven Digital Biosensing: Predictive Biocomputed Nano-Bio Interface for Intelligent Detection of Neurotoxic Contaminants in Water

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Abstract

Smarter approaches to environmental monitoring are needed to address the growing threat of toxic pesticides in water supplies, moving beyond conventional laboratory tests toward predictive systems. Aiming to develop an intelligent digital solution, a new cyber-physical framework has been conceived that virtually redefine how biosensors could be used. A python algorithm has been built to simulate the detection process prior to real-world experimentation. The user-friendly graphical interface lets the operator simply input key water quality parameters, including pH level, temperature, salinity, turbidity, BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), and total suspended solids (TSS). The program evaluates how a tyrosinase-based biosensor would perform when placed in a given water sample. Using deep neural networks (DNN), the system learns from recent published research studies and technical reports, pulling in real data about detection limits (LOD), quantification limits (LOQ), reaction speeds, and how different nanomaterials improve sensitivity. This powerful machine learning (ML) based algorithm is able to predict the smallest concentration of pesticide the sensor can detect, and whether other substances in the water might interfere with the measurement. The predictive system forecasts the sensor's performance with confidence levels and recovery rates, effectively allowing users to test their water sample in a virtual environment before ever touching a lab bench. This work directly paves the way toward creating a smart and digital tool that offers a practical and accessible way to assess water quality through preliminary virtual experiments.

Keywords: Pesticide detection, Digital biosensing, Pesticide detection, Tyrosinase, Water quality monitoring.

Intensification of Sessile Droplet Evaporation by Mechanical Vibrations

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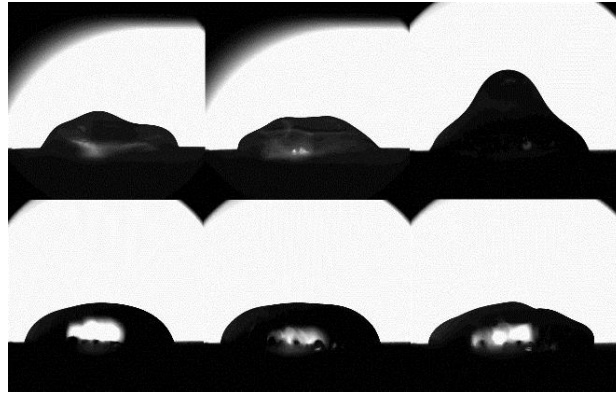
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Abstract

This experimental study examines the influence of vibrational excitation on the evaporation of sessile droplets, with the aim of increasing evaporation fluxes and improving the performance of thermal desalination processes. The objective is to enhance evaporation kinetics, a key parameter for improving the productivity and efficiency of thermal systems [1–3]. A comparison between a droplet subjected to vibration at its resonance frequency and a stationary droplet reveals a significant acceleration of the evaporation process under the effect of vibrations. Substrate vibration disturbs the boundary layer near the liquid–gas interface, reducing diffusive resistances. Furthermore, the induced dynamic deformations increase the liquid–gas exchange surface area, thereby intensifying heat and mass transfer. The results of this study show that vibration accelerates evaporation, leading to a 20.6% reduction in drying time on PTFE substrates and a 23.5% reduction on glass substrates compared to a non-vibrating droplet [4]. These findings highlight the potential of mechanical vibrations as a promising strategy for intensifying thermal desalination processes.

Keywords: evaporation, sessile droplet, vibration, resonance frequency



A sequence of images showing the temporal evolution of a sessile water droplet subjected to vibrations [4]

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Effects of Interactions on Evaporation Kinetics in Sessile Multi-Droplet Configurations

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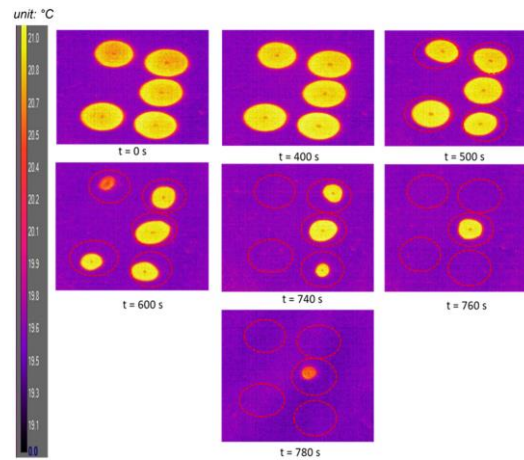
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Abstract

Understanding droplet-scale evaporation mechanisms is essential for optimizing thermal desalination processes, whose performance depends on the intensification of heat and mass transfer. This issue has been extensively described by de Gennes et al. [1]. Modeling sessile droplets deposited on a solid substrate is a complex task due to the coupling of capillary, thermal, and diffusive phenomena in a system characterized by low dimensionality. Under real-world conditions, droplets are generally not isolated but interact with neighboring droplets, which alters the surrounding vapor field and influences evaporation kinetics. Experimental investigation of this phenomenon, along with measurements of associated physical fields (evaporated mass, temperature, and velocity field), remains a scientific challenge that requires further study [2]. In this work, we investigate the competitive evaporation of multiple droplets arranged in a nonlinear configuration. The results show that the presence of adjacent droplets induces a diffusive shielding effect, reducing the vapor concentration gradient around the central droplet and thereby slowing its evaporation. Conversely, droplets located at the extremities of the arrangement evaporate more rapidly due to weaker diffusive interactions [3,4]. These observations confirm that inter-droplet interactions must be considered in modelling evaporative fluxes to improve the prediction and optimization of thermal desalination processes.

Keywords: evaporation, multi-droplets, shielding effect



Snapshots of the evaporation process of a sessile multi-droplet arrangement [4]

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A Metrological Approach to Potentiometric pH Measurement in Artificial Seawater: Implications for Desalination Processes

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Abstract

Accurate pH measurement in high-salinity environments is critical for desalination process control, scaling prevention, and chemical conditioning of seawater. However, potentiometric measurements in concentrated saline matrices are affected by high ionic strength, activity coefficient deviations, and liquid junction potentials, leading to significant systematic biases when conventional calibration procedures are applied.

This work presents a metrologically structured investigation of potentiometric pH measurements in sulfate-free artificial seawater (ASW) as a controlled model system representative of desalination feed water. Experimental measurements are combined with thermodynamic modeling based on the Pitzer formalism to quantify activity effects and evaluate discrepancies between empirical calibration and model-corrected values. Electrode performance, stability, and drift are assessed under high ionic strength conditions, and a comprehensive uncertainty analysis is performed to characterize measurement reliability.

Results demonstrate that matrix-induced deviations can significantly affect apparent pH values, potentially impacting process optimization and scaling prediction in desalination systems. The proposed framework enhances the robustness, comparability, and traceability of pH measurements in saline environments and supports improved analytical control in water treatment applications.

Keywords: pH, artificial seawater, traceability, potentiometry, Desalination processes, Pitzer model.

Valorization of Agricultural Waste into High-Performance Bioadsorbents for Dye Removal

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Abstract

The rapid global increase in waste generation, reaching billions of tons annually, demands innovative and sustainable strategies aligned with circular economy principles. In this framework, the valorization of agricultural residues into functional materials represents a promising pathway to reduce environmental burdens while creating value-added products. Simultaneously, wastewater contamination by synthetic dyes remains a critical environmental and public health concern due to their persistence, toxicity, and resistance to biodegradation. Addressing these challenges requires integrated and sustainable treatment solutions.

This study explores the conversion of agricultural waste into eco-friendly and low-cost bioadsorbents for the efficient removal of dyes from aqueous solutions. The adsorption performance was systematically investigated by examining the effects of key operational parameters, including solution pH, initial dye concentration, and adsorbent dosage. The results demonstrate a high adsorption efficiency, highlighting the strong potential of agricultural waste-derived materials as sustainable alternatives to conventional adsorbents. This approach contributes to minimizing solid waste generation, reducing reliance on non-renewable resources, and promoting environmentally responsible wastewater treatment processes. By integrating waste valorization with pollution control, this research supports the transition toward sustainable development and circular economy models, offering a practical and scalable solution for addressing interconnected challenges related to resource management, environmental protection, and industrial wastewater treatment.

Keywords: Adsorption, Wastewater remediation, Eco-friendly materials, Environmental sustainability, Dyes, Optimization

Secondary Effluent Quality Improvement for Agricultural Reuse Using maturation ponds

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Abstract

The reuse of wastewater is considered an excellent approach to addressing water scarcity. Possible applications for reusing treated wastewater (TW) include agricultural irrigation, groundwater recharge, industrial activities, street cleaning, and ecological uses. The use of TW for agricultural purposes is essential, particularly in the semi-arid areas of the Mediterranean basin, where agriculture is the largest consumer of water (around 60% in Algeria). It offers a promising way to mitigate the risks to global water resources and ensure water sustainability, particularly in agricultural areas of northern Algeria, such as the Oran region. In agriculture irrigation, TW offers significant economic and environmental benefits, such as the possibility of recovering nutrients or reducing fertilizer use. However, the risks associated with the presence of emerging contaminants of concern (ECCs) or pathogenic microorganisms in secondary effluent suggest the need to implement effective and relatively inexpensive tertiary treatments. With this aim, a lagooning system consisting of three basins connected in series was set up as an alternative tertiary treatment in a conventional wastewater treatment plant in the Oran region. This study determined the effectiveness of activated sludge process for *Escherichia coli* and fecal coliform bacteria reduction. The results show that the system was able to reduce physicochemical parameters within irrigation standards except for the microbiological parameters. It is concluded that lagooning system exposed to sunlight is a viable option for the treatment of secondary effluent for reuse purposes. However, further studies should be conducted especially on the key role that sunlight disinfection plays in natural systems and the potential to enhance this process in engineered systems for the removal of microbial parameters.

Keywords: Wastewater Reuse; Reclaimed Water; Safe Agricultural Reuse; Emerging Contaminants

Plasma chemical mineralization of Per-and polyfluoroalkyl substances by dielectric barrier discharge

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Abstract

Per- and polyfluoroalkyl substances (PFAS), particularly perfluorooctanoic acid (PFOA), are persistent organic pollutants widely detected in aquatic environments and of significant concern due to their high chemical stability and resistance to conventional treatment methods. This study investigates the degradation of PFOA in water using an innovative non-thermal plasma process based on dielectric barrier discharge (DBD). Treatment efficiency was evaluated through the monitoring of selected physicochemical parameters and liquid chromatography mass spectrometry analysis of PFOA removal and transformation products. The results indicate that non-thermal plasma promotes partial degradation and mineralization of PFOA, achieving approximately 40% removal after 30 minutes of treatment under the investigated conditions. Treatment performance was influenced by plasma operating parameters and the discharge environment, highlighting the important role of reactive species generated during plasma-liquid interactions. These findings demonstrate the potential of plasma-based advanced treatment processes for PFAS-contaminated water and provide a foundation for further optimization and application to complex environmental matrices.

Keywords: water treatment, persistent pollutants, non-thermal plasma, dielectric barrier discharge, PFAS

Valorization of Deglet Nour Date Sorting By-Products into Date Syrup for Kefir Fortification: Water, Carbon and Environmental Sustainability Assessment

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Abstract

In Mediterranean regions, increasing water scarcity and environmental constraints call for sustainable agri-food processes that minimize water consumption, greenhouse gas emissions, and ecosystem degradation. This study investigates an integrated and eco-oriented approach based on the valorization of Deglet Nour date sorting by-products for the production of date syrup and its subsequent incorporation into milk kefir as a natural functional ingredient.

Date fruits excluded from the commercial market due to size or visual defects were selected as raw material, contributing to food waste reduction and circular economy practices. The syrup was produced through an aqueous extraction process involving washing, maceration, filtration and thermal concentration, avoiding the use of chemical solvents. The obtained date syrup was then used to partially replace refined sugar in milk kefir formulation, providing fermentable sugars and bioactive compounds while enhancing sensory properties. From an environmental perspective, the valorization of date by-products showed a positive impact on nature conservation by reducing agricultural waste and promoting the use of local renewable resources. The water footprint of the process was mainly associated with washing and extraction steps; however, it remained limited compared to conventional sugar production, which requires intensive irrigation and industrial refining. The carbon footprint was primarily related to thermal energy demand during syrup concentration, representing the main environmental constraint, yet offering significant potential for optimization through process control and renewable energy integration. Overall, this integrated process demonstrates that the transformation of date sorting by-products into functional ingredients for fermented beverages can contribute to reducing water and carbon footprints while supporting sustainable food systems adapted to Mediterranean environmental challenges.

Keywords: Date syrup, Water footprint, Carbon footprint, Circular economy, Sustainable fermented beverages.

Groundwater treatment using subsurface constructed wetland systems

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Abstract

Desalination and groundwater treatment remains a challenge worldwide. Sustainable development and environmental protection have added another challenge in recent years, alongside the first: the use of sustainable and cost-effective techniques such as constructed wetland systems. In the present study, a pilot plant consisting of two vertical subsurface flow constructed wetlands (VSSFCW) and a horizontal subsurface flow constructed wetland (HSSFCW) planted with cattails, was implemented to evaluate the performance of CWs in treating groundwater extracted from Sfax, Tunisia. The determination of the pilot plant characteristics, such as pH, temperature, electrical conductivity (EC), and dissolved Oxygen (DO), proves that they are favorable for the biological treatment of groundwater, the growth of macrophytes, and the development of the bacterial environment. CWs result in a good elimination of total suspended solids, organic matter, and hardness (TH). A maximum removal efficiency of 34.8% for TSS, 20% for COD, 47% for BOD_5 and 23.4% for TH is obtained. The main removal efficiency was for TSS and BOD. Next, the paper sheds light on the most efficient basin in pollutant removal: remarkable removal efficiency for TSS (50%), COD (21%), BOD_5 (95.4%) and hardness (27.5%) was obtained by HSSFCW. Basin (3) even contributes to correcting the disturbance caused by basin (2). It was found out that TSS was mainly removed by VSSFCW through the filtration process, while OM was removed by HSSFCW through bacterial activity.

Keywords: Groundwater; Constructed wetlands; Organic matter; TSS; Water Hardness; Macrophytes.

From Reactive to Proactive: Machine Learning and Multimodal Sensors in Next-Gen Smart Water Grids for Livestock Farming and Animal Health

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Abstract

The Next-Gen Smart Water Grid (SWG) initiative, highlighted in 2025–2026 industrial benchmarks, represents a shift from traditional “monitor and react” strategies to a proactive “sense and optimize” framework. When applied to animal farming, this approach extends to water supply systems, where water quality constitutes a critical determinant of animal health and productivity. The system relies on an Internet of Things (IoT) network of multimodal sensors, including high-frequency pressure transducers, nano-sensors, and UV-Vis spectroscopic probes, and is deployed across distribution and treatment infrastructures. Integrated into wells, storage tanks, pipelines, and drinking troughs, these sensors continuously monitor physicochemical and microbiological parameters (pH, turbidity, nitrates, ammonia, salinity, and microbial contamination). Moreover, data streams feed a centralized Digital Twin powered by Physics-Informed Neural Networks (PINNs), simulating hydraulic behavior and contaminant dispersion in real time. The Digital Twin models not only monitor water flow but also evaluates the effects of water quality variations on animal performance. Machine Learning architectures, including Ensemble Learning models such as Random Forest and XGBoost, achieve a high percentage of accuracy in anomaly detection, distinguishing routine demand shifts from contamination events or infrastructure failures. This supports early identification of waterborne contaminants and mineral imbalances that may impair rumen function, digestive stability, and overall animal well-being, thereby strengthening preventive veterinary management. This AI-driven framework transforms water management into a dynamic system that enhances environmental sustainability while protecting livestock health.

Keywords: Smart Water Grid (SWG); Digital Twin; Livestock Water Quality; Machine Learning (ML); Animal Well-Being.

Valorization of Coffee grounds for methylene blue Removal from water

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Abstract

Water pollution by synthetic dyes constitutes a critical environmental issue, particularly in developing countries where industrial discharges are often poorly treated. Among these dyes, methylene blue (MB) is widely used in the textile and pharmaceutical industries, and its presence in wastewater poses a threat to aquatic ecosystems and human health. In this study, we investigated the removal of methylene blue by adsorption onto coffee grounds, an abundant and low-cost organic residue. The coffee grounds were prepared, dried, and characterized. Response surface methodology (RSM) was used to optimize the experimental conditions in the adsorptive removal of MB from aqueous solution using Coffee grounds. The studied parameters are MB concentration, the pH of the solution, the temperature, the adsorbent mass and the stirring speed. The analysis of variances (ANOVA) showed that the quadratic model of MB removal rate is highly significant ($R^2 = 0.986$). The desirability study shows that we can reach a maximum rate of 99.20% at 0.7 g of adsorbent, MB concentration of 100 mg/L, pH 6, agitation speed of 75 rpm, and temperature of 55 °C. The adsorption isotherm and the kinetics study were carried out using the optimum conditions determined previously. The correlation coefficients and the values of the "Chi-square" test show that the adsorption can be described according to the Freundlich model and that the adsorption kinetics follow the pseudo-second-order model.

In conclusion, this study demonstrates that Coffee grounds can be effectively used as a bioadsorbent for the removal of methylene blue from wastewater, combining performance, accessibility, and environmental sustainability. This process represents a promising approach for the valorization of organic waste while providing a sustainable solution to water pollution.

Keywords: adsorption, coffee grounds, response surface methodology, kinetics models, methylene blue.

High-Efficiency Removal of Copper and Nickel via Donnan Dialysis Using Fujifilm Cation-Exchange Membranes: Process Optimization through Response Surface Methodology

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Abstract

This study investigates the simultaneous removal of copper and nickel ions from aqueous solutions using Donnan dialysis (DD), with process optimization performed through Response Surface Methodology (RSM). An initial screening identified the most effective counter-ion, guiding the experimental design toward optimal ion removal. Comparative experiments using Fujifilm Type 1 and Type 2 cation-exchange membranes revealed the superior performance of Type 1 for both metals, as confirmed by FTIR-ATR spectroscopic analysis of membrane morphology. A comprehensive experimental campaign based on a Central Composite Design (CCD) evaluated the effects of copper, nickel, and sodium ion concentrations on removal efficiency. Under optimized conditions—80 mg/L Cu²⁺, 100 mg/L Ni²⁺, and 0.06 mol/L Na⁺—the Fujifilm Type 1 membrane achieved remarkable removal rates of 99.67 ± 0.21% for copper and 98.85 ± 0.34% for nickel. These values were experimentally validated (99.45 ± 0.18% and 98.71 ± 0.27%, *n* = 3), showing excellent agreement between predicted and observed data and confirming the robustness of the optimized Donnan dialysis process. Overall, the results highlight Donnan dialysis as a highly efficient and environmentally sustainable approach for the removal and recovery of heavy metals from aqueous solutions using Fujifilm cation-exchange membranes.

Keywords: Donnan dialysis; Fujifilm cation-exchange membranes; copper; nickel; response surface methodology.

Optimizing Weighted Electroflocculation for Efficient Water Hardness Reduction: Insights from ANOVA and Tukey HSD Analyses

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Abstract

The increasing demand for high-quality freshwater, driven by population growth and climate change, highlights the urgent need for efficient water treatment technologies. Water hardness caused by Ca^{2+} and Mg^{2+} ions remain a major challenge for domestic and industrial uses, while conventional softening methods are often limited by high costs, energy consumption, and secondary waste generation.

This study investigates the performance of weighted electroflotation (EFL) for water hardness removal, focusing on the evaluation of key operational parameters, including flow rate, micro-sand dose, polyethyleneimine (PEI) polymer dose, current intensity, and agitation speed. Experimental results demonstrated that under optimal conditions—18 L/h flow rate, 4 g micro-sand combined with 5 mL PEI, 2 A current intensity, and 30 rpm agitation speed—hardness removal efficiencies exceeded 93%. Statistical validation using ANOVA and Tukey HSD tests confirmed the significance of the operational parameters and their combined effects.

The findings highlight that the combined adjustment of process conditions significantly enhances floc formation and settling efficiency. This work introduces an innovative integrated approach for weighted electroflotation, demonstrating its potential as a cost-effective and sustainable alternative for advanced water softening applications.

Keywords: Water hardness removal, Electroflotation (EFL), Operational parameters optimization, Ca^{2+} and Mg^{2+} ions

Biomass (date palm by-product) valorization via Synthesis of plastic polymer membrane (PPM)

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Abstract

This study reports the development of a plasticized polymer membrane (PPM) for the selective separation of Ni(II) ions. The membranes were prepared by cellulose triacetate (CTA) synthesized from an interesting non-woody material (date palm seeds) as base polymer. Di-(2-ethylhexyl) phosphoric acid (D2EHPA) was used as carrier. The addition of tris (2-butoxyethyl) phosphate (TBEP), 2-Nitrophenyloctylether (2NPOE) or 2-Nitrophenylpentylether (NPPE) as plasticizers was investigated. The obtained films were characterized by the Fourier Transformed Infrared Spectroscopy FTIR; Scanning Electron Microscopy (SEM). Measurement of the contact angle gives information about the hydrophobicity and roughness of the membrane. The mechanical properties of the membrane are obtained by the measurement of the tensile strength. The effects of membrane composition such as the plasticizer type and the carrier amount were investigated on nickel ions separation. The transport of Ni (II) through the PPM was investigated by evaluating the initial flux. It can be perceived that the PPM containing 2NPPE as plasticizer and 35 % (w/w) of carrier assured maximum Ni (II) transport. Furthermore, the PPM is effective for long-term separation processes. Overall, these findings demonstrate the strong potential of bio-based CTA membranes as efficient, sustainable, and high-performance materials for advanced nickel separation applications.

Keywords: Plasticized polymer membrane; Cellulose triacetate; Nickel(II) transport; D2EHPA; Bio-based materials

Performance Evaluation of a Poly(vinyl chloride) Polymer Inclusion Membrane Containing 2-Nitrophenyl Octyl Ether and Di(2-ethylhexyl) Phosphoric Acid for Heavy Metal Separation from a Ternary Solution

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Abstract

The contamination of water resources by heavy metals represents a major threat to the environment and human health, highlighting the urgent need for efficient technologies that enable both their removal and recovery. In this context, membrane-based separation processes, particularly polymer inclusion membranes (PIMs), have attracted increasing attention due to their high selectivity and suitability for the treatment of dilute effluents. A polymer inclusion membrane based on poly(vinyl chloride) (PVC), plasticized with 2-nitrophenyl octyl ether (NPOE) and containing di(2-ethylhexyl) phosphoric acid (D2EHPA) as a carrier, was developed for the selective separation of metal ions from a ternary aqueous solution. The results demonstrate the high efficiency and strong potential of the synthesized PIM for the selective recovery of heavy metals, confirming its relevance for wastewater treatment and resource recovery applications.

Keywords : PIM, D2EHPA, Recovery, Separation, Heavy metal ions.

A Comparative Study of Raw Chert and Biomass-Derived Carbon for the Adsorptive Removal of Congo Red and Methylene Blue: Performance and Mechanisms

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Abstract

The discharge of synthetic dyes into aquatic environments represents a major environmental concern due to their toxicity, persistence, and resistance to biodegradation. Congo Red (CR) and Methylene Blue (MB) are among the most frequently detected anionic and cationic dyes in industrial effluents. In this study, raw chert and a non-activated carbon derived from *Posidonia oceanica* carbonized at 700 °C were evaluated as low-cost and eco-friendly adsorbents for dye removal from aqueous solutions. Batch adsorption experiments were carried out to investigate the effects of initial dye concentration and solution pH on adsorption performance. The results revealed significant differences between the two materials. Raw chert exhibited remarkably higher adsorption capacities, reaching 140.84 mg/g for MB and 112.35 mg/g for CR, compared to 16.36 mg/g and 29.67 mg/g, respectively, for the non-activated carbon. These findings highlight the strong adsorption potential of chert despite its natural and unmodified nature. The adsorption process was strongly influenced by solution pH, with CR removal favored under acidic conditions, whereas MB adsorption increased at alkaline pH, suggesting the involvement of electrostatic interactions. Kinetic data were well described by the pseudo-second-order model. Furthermore, equilibrium data fitted the Langmuir isotherm model, supporting monolayer adsorption on relatively homogeneous surfaces.

Overall, this study demonstrates that raw chert is a highly efficient and promising adsorbent for dye-contaminated wastewater treatment. Its superior performance compared to non-activated carbon, combined with its natural abundance and minimal processing requirements, makes it a strong candidate for sustainable and cost-effective water remediation applications.

Keywords: Chert, Raw carbon, *Posidonia oceanica*, Dyes, Wastewater treatment.

Valorization of Mollusk Shells as Bio-Adsorbent and Bio-Coagulant for Industrial Wastewater Treatment

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Abstract

This study focuses on the valorization of mollusk shells, a biomass rich in calcium carbonate (CaCO_3), as bio-adsorbents and bio-coagulants for the treatment of industrial wastewater. Two approaches were explored: the adsorption of Methylene Blue using ZnCl_2 -activated shells combined with smectite clay, which demonstrated the best performance through enhanced microporosity and improved cationic exchange, and coagulation-flocculation using calcined shells, reducing the turbidity of an industrial effluent from 286 NTU to 93 NTU at an optimal dose of 2.5 g/L. Optimization of the parameters (dose, pH, contact time) using the Box-Behnken design (RSM) achieved approximately 90% removal of both turbidity and COD, confirming the effectiveness of this low-cost approach within a circular economy framework. Future perspectives include application to other dyes, kinetic modelling, and scale-up to pilot level.

Keywords: Mollusk shells · Adsorption · Methylene Blue · Coagulation · Turbidity · COD · Box-Behnken · RSM

Effect of radiocatalysis on the degradation of chlorinated organic and pyrethroid pesticides

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Abstract

Widely used in agriculture and vector control during the mid-20th century, pyrethroid and organochlorine pesticides raise serious concerns due to their significant threats to human health and biodiversity. Recently, many compounds of pyrethroid and organochlorine group are banned for use in many countries across the world due to their persistence and bioaccumulation in the environment. The aim of the present work is to study the degradation in aqueous solutions of some pyrethroid and organochlorine compounds (Dieldrin, Lambda-cyhalothrin) using chemical processes such as radiolysis. The experiments involved the use of irradiation combined with catalysts (radiocatalysis) for the degradation of pesticide molecules in aqueous solutions. The trials were conducted in triplicate at room temperature, and the efficiency of the degradation was monitored for six gamma irradiation doses (0.1, 0.2, 0.3, 0.6, 0.95, and 1.25 kGy) by measuring pH, oxygen consumption, and pesticide concentrations using UV-visible spectrometry and gas chromatography-mass spectrometry (GC-MS).

Radiocatalysis of lambda-cyhalothrin showed a degradation of more than 50% of the initial amount in aqueous solution at the highest gamma irradiation dose. However, no effect of radiocatalysis was observed for Dieldrin. The results indicated that the efficiency of pesticide degradation by radiocatalysis depends largely on the chemical properties of the pesticide, so irradiation doses must be adjusted accordingly.

Keywords: Pesticide, Lambda-cyhalothrin, Dieldrin, Degradation, Radiocatalysis

Integrated Eco-Chemical Approach for the Treatment of Detergent Industry Effluents: Combination of Foam Fractionation and Adsorption onto Activated Biochar

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Abstract

Effluents generated by detergent manufacturing industries contain surfactants and persistent organic compounds that are responsible for significant environmental impacts. Conventional treatment processes often exhibit limited efficiency in removing these surface-active pollutants. This study proposes a combined and sustainable strategy integrating foam fractionation and adsorption onto activated biochar for the selective and eco-efficient removal of surfactants.

In the first stage, foam fractionation will be optimized by investigating key operational parameters, including pH, air flow rate, column height, and treatment time, in order to maximize the extraction of free surfactants at the air–water interface. In the second stage, activated biochar derived from Tunisian agricultural residues collected in the Saouaf region (Zaghouan Governorate) will be prepared and thoroughly characterized to serve as an adsorbent in a polishing step for the pretreated effluent.

The performance of the combined process will be assessed through reductions in chemical oxygen demand (COD), total organic carbon (TOC), and surfactant concentration, along with biological toxicity assays. Preliminary expected outcomes indicate a significant enhancement in treatment efficiency and a marked decrease in residual organic load. This innovative coupling, based on the valorization of locally sourced bio-based materials, is fully aligned with the principles of green chemistry and the circular economy, and offers promising prospects for low-environmental-impact industrial applications.

Solar Photocatalysis via WO₃ Immobilization on TiO₂-K10: A sustainable strategy for Visible-Light-Driven Water Treatment.

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Abstract

Solar photocatalysis offers a sustainable solution for environmental remediation; however, the limited visible-light activity of TiO₂ remains a critical barrier to efficient solar energy utilization. TiO₂ is widely recognized as a leading UV-photocatalyst due to its exceptional chemical stability, non-toxicity, and low cost, yet its wide band gap severely restricts its visible-light response. In this work, a novel strategy was developed for the elaboration of WO₃-immobilized TiO₂-K10 composites to overcome these intrinsic limitations. Montmorillonite K10 was selected as a natural, high-surface-area clay support due to its strong adsorption capacity, excellent dispersion properties, and ability to stabilize immobilized photoactive phases, thereby improving photocatalyst accessibility and efficiency under solar irradiation.

Comprehensive physicochemical characterization using XRD, FTIR, nitrogen physisorption, SEM-EDX, TGA, and XPS confirmed the successful immobilization of WO₃ and the formation of structurally stable composite materials. The photocatalytic performance was evaluated through the solar degradation of 4-nitrophenol as a model organic pollutant. The optimized composite containing 5 wt% WO₃ achieved 89% degradation efficiency, compared to only 12% for the WO₃-free material, demonstrating a remarkable enhancement in visible-light photocatalytic activity. This improvement is attributed to the synergistic interaction between immobilized WO₃, TiO₂, and K10, which enhances visible-light absorption, facilitates interfacial charge transfer, and significantly reduces electron-hole recombination.

This work provides a facile, low-cost, and environmentally sustainable approach for the elaboration of efficient clay-based visible-light photocatalysts and highlights the strong potential of WO₃-immobilized TiO₂-K10 composites for solar-driven water treatment.

Keywords: Visible-light photocatalysis, Sustainable Solar Water treatment, WO₃-immobilized TiO₂-K10 composites, Immobilized tungsten species, 4-Nitrophenol degradation

Electron Beam Irradiation for the Degradation of Persistent Pharmaceutical Pollutants in Aquatic Systems

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Abstract

Pharmaceutical residues in aquatic environments pose significant threats to aquatic ecosystems and potentially to human well-being due to their biological activity, persistence, and continuous discharge from wastewater treatment plants. Non-steroidal anti-inflammatory drugs such as Ibuprofen, Diclofenac, Ketoprofen, along with transformation products such as 2,6-dichloroaniline, are frequently detected in surface and wastewater systems and are resistant to conventional treatment processes. This study introduces electron beam (EB) irradiation as an innovative and efficient advanced oxidation technology for the degradation of these recalcitrant pharmaceutical compounds.

The influence of key operational parameters—including initial pollutant concentration, absorbed dose, reactor configuration, and oxidant addition—was optimized. EB irradiation achieved high degradation efficiencies accompanied by substantial reductions in chemical oxygen demand (COD) and total organic carbon (TOC), indicating effective mineralization of the target compounds. The addition of hydrogen peroxide (H₂O₂) and persulfate (PS) enhanced removal performance through increased radical production, whereas methanol addition reduced degradation efficiency due to radical scavenging effects.

The findings demonstrate that EB irradiation is a powerful and scalable solution for the treatment of persistent pharmaceutical contaminants and represents a promising approach for large-scale industrial wastewater remediation.

Keywords: Electron beam irradiation, Pharmaceutical pollutants, Advanced oxidation process, Persulfate activation, Wastewater treatment

Biosorption Using *Artemisia campestris* Biomass for Water Treatment and Desalination

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Abstract

Water resource pollution and increasing salinity have become major environmental challenges worldwide. Conventional water treatment and desalination technologies, such as reverse osmosis and distillation, are effective but often costly and energy-intensive. In this context, biosorption using plant biomass has emerged as an eco-friendly and cost-effective alternative for water purification.

Artemisia campestris is a plant rich in cellulose, hemicellulose, lignin, and phenolic compounds, which contain several active functional groups such as hydroxyl, carboxyl, and amine groups. These groups are capable of binding different pollutants present in water. Consequently, the biomass of this plant can act as a natural biosorbent for the removal of heavy metals, dyes, and certain dissolved ions from industrial effluents and brackish water.

The biosorption mechanism mainly involves surface adsorption, ion exchange, and chemical complexation between the functional groups of the biomass and the dissolved ions. These interactions contribute to the reduction of pollutant concentrations and may also help decrease water hardness and salinity.

The efficiency of the biosorption process depends on several experimental parameters, including pH, initial ion concentration, biosorbent dosage, temperature, and contact time. In addition, chemical or thermal modification of the biomass can enhance its specific surface area and increase the number of active sites, thereby improving adsorption capacity.

Therefore, the use of *Artemisia campestris* biomass represents a promising and sustainable approach for the treatment of contaminated water and as a potential pretreatment step in desalination processes.

Keywords: Biosorption; *Artemisia campestris*; Water treatment; Desalination; Plant biomass

Feeding specturum of young hybrid sparrow (*Passer domesticus* x *P. hispaniolensis*) in the oasis environment of Hassi Ben Abdellah, Algeria.

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Abstract

The study examines the diet spectrum of young *Passer domesticus* x *P. hispaniolensis* in a date palm environment in Hassi Ben Abdellah, Algeria. The research aims to fill a gap in knowledge regarding the trophic aspect of young hybrid sparrows in an oasis environment. Sixty young sparrows were collected from nests, categorized into three age groups (1-4 days, 5-8 days, and 9-12 days). The stomach contents of the sparrows were analyzed to identify prey items. Stomach content analysis revealed that insects make up a large part of the diet of young sparrows, with 94.7% of prey items consisting of insects for sparrows aged 1-.days, 94.5% for those aged 5-8 days, and 90.0% for those aged 9-12 days 4

The trophic menu of young sparrows is characterized by the dominance of heteropteran prey particularly Lygaeidae, in chicks aged 1-3 days. The other age categories mainly consume soft-bodied prey such as Pheidole pallidula(Hymenoptera) caterpillars , (Lepidoptera) and Diptera.

Keywords: diet spectrum, young *Passer domesticus* x *P. hispaniolensis*, Hassi Ben Abdellah.

Productivity enhancement of single slope solar distiller by using convex absorber: an experimental study

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Abstract

This experimental study targets to enhance the productivity of the single slope solar distiller (SSSD) by using a convex absorber in lieu of the flat absorber. To attain this objective, temperatures and productivity were led for comparing the impact of employing the convex absorber on the performance of the SSSD. In this case, two SSSDs were fabricated and tested under the identical ambient conditions of Sfax region central–eastern Tunisia, viz., SSSD with flat absorber (SSSD–FA) and SSSD with convex absorber (SSSD–CA). The experimental results revealed that the using of convex absorber (SSSD–CA) increases the productivity by 28% when compared to the SSSD–FA. The maximum seawater temperature of SSSD–FA and SSSD–CA reached 68 °C and 73 °C, respectively, as a result of the minimum reduction of the water depth in the used absorber of distiller.

Keywords: Single slope solar distiller; Convex absorber; Flat absorber; Temperature; Productivity.

Improving Biogas Production from Agro-Food Waste Using Artificial Intelligence and Deep Learning: A Review of Recent Research

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Abstract

Optimizing biogas production from agro-food organic waste remains a critical challenge due to the heterogeneous nature of feedstocks and the complex, highly nonlinear behavior of the anaerobic digestion (AD) process. This review provides a comprehensive synthesis of recent advances (2022–2026) in the application of Artificial Intelligence (AI) and Deep Learning (DL) techniques to enhance methane yield, strengthen process monitoring, and improve operational reliability across biogas systems treating agro-food waste.

Recent studies demonstrate the strong predictive capability of machine-learning and deep-learning models—including Long Short-Term Memory (LSTM) networks, Recurrent Neural Networks (RNN), Random Forest (RF), and Extreme Gradient Boosting (XGBoost)—in forecasting key performance indicators such as biogas output, methane concentration, digester stability, and nutrient dynamics. These models enable accurate estimation of critical AD parameters (e.g., pH, temperature, organic loading rate, hydraulic retention time), supporting real-time decision-making and advanced process control strategies.

In parallel, hybrid optimization frameworks integrating ML algorithms with meta-heuristic approaches (e.g., genetic algorithms, particle swarm optimization) have shown significant potential for maximizing methane yield, improving process robustness, and enhancing energy recovery within circular bioeconomy systems. The increasing adoption of Explainable Artificial Intelligence (XAI) further strengthens model interpretability, enabling clearer identification of influential operational factors and more transparent optimization pathways.

While challenges persist—including data scarcity, limited model transferability across digester scales, and the need for more interpretable algorithms—the collective body of evidence indicates

that AI-enabled workflows offer transformative opportunities for scaling up sustainable, efficient, and resilient biogas production from agro-food waste.

Keywords:

Anaerobic digestion, Methane yield optimization, Agro-food waste, Artificial intelligence, Deep learning.

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