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SUMMARY

Versatile multifunctional mixed oxide catalysts obtained from layered double hydroxide precursors

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Introduction

The anionic clays known as layered double hydroxides (LDH) or hydrotalcites have the general formula $[(M^{2+})_{1-x}(M^{3+})_x(OH)_2]^{x+}(A^{n-})_{x/n}\cdot mH_2O$, where M^{2+} and M^{3+} are bivalent and trivalent cations, respectively, with ionic radii close to that of Mg^{2+} and $0.2 \leq x \leq 0.4$ [1]. They have a layered structure resulting by stacking of two-dimensional brucite-like sheets of edge-sharing octahedra of hydroxyl groups with the cations homogeneously distributed in the octahedral sites. The positive charge brought by the M^{3+} cations partially replacing M^{2+} cations in the brucite-like layers can be compensated by a wide range of inorganic or organic interlayered anions A^{n-}, including heteropolyanions and metal complexes [1]. Several different cations, including transition metals, can simultaneously be present in the brucite-like sheets leading to multicationic LDH. Due to their structure, together with their compositional flexibility, the LDH possess versatile physicochemical properties, which make them excellent candidates as multifunctional nanostructured catalysts and catalyst precursors [2]. Indeed, their controlled thermal decomposition leads to homogeneous mixed oxide structures with relatively high surface areas, good thermal stabilities and tunable both acid-base and redox properties, which make them very attractive multifunctional oxide-based catalysts [2].

Results

The acid-base properties of ex-LDH M-MgAlO mixed oxides, where M is a transition metal or a rare earth cation, depend on the nature of the cation M [3] and, for a given cation M, on its content [4] and on the Mg/Al mol ratio [5], with huge consequences on their catalytic behavior. At the same time, their redox properties depend on the nature of the cation M [2, 6] and, for a given cation M, on its content [2, 6, 7] and on the presence of a second or even a third variable-valence cation [2, 8], which strongly affect their catalytic performance in processes involving a heterogeneous redox mechanism. These results will be systematically presented, pointing out the remarkable catalytic behavior of transition-metal-containing ex-LDH mixed oxide catalysts in correlation with their physicochemical characteristics in various processes such as, benzyl alcohol hydrodeoxygenation, ethanol conversion, propane oxydehydrogenation and methane total oxidation.

Conclusion

Transition-metal-containing M-MgAlO mixed oxides obtained from LDH precursors possess both acid-base and redox properties acting as multifunctional catalysts in various processes.

***Keywords*— layered double hydroxides; mixed oxides; catalysts; acid-base properties; redox properties.**

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Integrated Optimization of Battery and Hydrogen Systems in Hybrid Renewable Energy Configurations for Industrial Decarbonization

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ABSTRACT

Introduction: Industrial decarbonization requires energy systems capable of reducing costs, emissions, and grid dependence under variable renewable energy conditions [1]. Hybrid renewable energy systems (HRES), combining photovoltaics, wind turbines, batteries, and hydrogen technologies, are promising solutions for industrial applications [2]. However, coordinated management of short- and long-term storage remains a major challenge. Therefore, this study investigates coordinated battery–hydrogen optimization in grid-connected HRES [3].

Research Question: How can coordinated optimization of battery and hydrogen subsystems reduce electricity costs, reliance on the grid, and CO_2 emissions in industrial HRES?

Methodology: The methodology models the complete electricity–hydrogen–electricity cycle, including electrolyzers, hydrogen storage tanks, fuel cells, and battery systems [4]. An Enhanced Tabu Search algorithm with adaptive memory is applied to optimize system operation and avoid repeated solution trajectories [3]. Heuristic scheduling prioritizes renewable energy utilization, while ε-constrained optimization evaluates economic and environmental trade-offs.

Results: Year-long simulations using industrial load profiles show that coordinated battery–hydrogen optimization significantly improves HRES performance compared with grid-only supply. Electricity costs decreased by up to 40%, grid reliance by 56%, and CO_2 emissions by approximately 30%. Batteries provide short-term flexibility, while hydrogen systems support long-duration balancing in the face of renewable variability [5].

Discussion: The results demonstrate that coordinated battery and hydrogen management improves economic performance, renewable energy utilization, and system autonomy while supporting industrial decarbonization objectives.

Conclusion: The proposed optimization framework enhances the efficiency and sustainability of industrial HRES. Coordinated battery–hydrogen operation represents a promising approach for increasing renewable energy integration and reducing industrial emissions. Future work will address scalability and broader industrial applications.

Keywords— **Hybrid renewable energy systems; battery storage; hydrogen systems; Enhanced Tabu Search; industrial decarbonization; optimization.**

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Pistachio Lentisque, a Natural Ally for the Development of Skincare Therapeutics

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ABSTRACT

The pistachio lentisque (*Pistacia lentiscus* L., Anacardiaceae. Abbreviation 'PL') is well known for its many benefits. It is traditionally used for the preservative effect of its leaves when steeped in drinking water, or as a remedy for burns using its fatty oil, for instance [1]. We previously designed a fully bio-based wound dressing containing PL essential oil and proved that it can treat pressure ulcers [2, 3]. Herein, we investigated the formulation of a PL-based dermocosmetic cream against acne as a complex, multifactorial skin condition [4]. Fatty oil from PL (PL-FO) was extracted via hot pression (Yield: 12.15%) and marjoram essential oil (*Origanum majorana* L., Lamiaceae) by hydrodistillation (Yield: 1.84%), while tea tree essential oil was obtained from the market. The bio-based formulation (aqueous phase = distilled water; oily phase = PL-FO + cetyl alcohol + essential oils; emulsifying surfactants = Polysorbate 80 + Sorbitan monooleate) was prepared using a high shear homogeniser (Ultraturrax®) through phase inversion, and the following parameters were adjusted: proportion of thickening agent = 5%; proportions of emulsifying surfactants: Polysorbate 80 = 4.455%, sorbitan monooleate = 0.545%; dispersion time = 5 min; dispersion speed = 8000 rpm. The resulting cream was hydrophilic, with a pH around 6 that is known to be skin-compatible and help combat acne [5]. Moreover, it exhibited a smooth texture, an optimal spreadability and a rapid penetration (<10 seconds). Stability tests under real conditions showed good microbiological stability over two weeks without preservatives, but a significant physical instability of the cream was recorded when exposed to temperature variations. Finally, the skin tolerance test demonstrated remarkable skin tolerance of the cream with no erythema, rash, or peeling.

In conclusion, PL contains an essential oil and a fatty oil that offer a wide range of applications, from the treatment of severe skin conditions (pressure ulcers) to dermocosmetic use. The inherent properties of these two compounds open up a wide range of opportunities in skin care.

***Keywords*— Pistachio lentisque, Skincare, Wound dressing, Biobased, Formulation.**

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Remote Sensing and GIS-Based Spatial Analysis for Enhanced Understanding of Soil Processes in Montado Agro-Silvo-Pastoral Systems

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ABSTRACT

Montado landscapes in Portugal are high-nature-value agro-silvo-pastoral systems that face ongoing declines in tree density and natural regeneration due to climate change [1], [2], [3] that deeply affects the resilience of the complex socio-ecological system [4]. The present research looks for further insights into this issue focusing on the effect of soil moisture regimes on soil-related processes. Soil moisture horizontal gradient was analyzed in Companhia das Lezírias, a long-term research site within the LTsER Montado platform, part of the European eLTER network. The objective of the study is to relate existing soil moisture patterns to soil parameters, focusing on carbon stocks, and detect soil hotspots.

SMI derived from Landsat-8 data for the period 2017-2024 was used to identify zones with different soil moisture intensity based on remote sensing data. Soil Moisture Index (SMI) was calculated, based on Landsat 8-9 OLI/TIRS C2 L1 data sets, Band 10 for years 2017, 2019, 2021 and 2023 for end of September. Persistent SMI patterns were identified by averaging annual values and classifying them into three categories [5].

Spatial interpolation revealed heterogeneous carbon distribution, with the northeastern sector consistently carbon-rich and the southwestern sector carbon-poor, partially corresponding to persistent soil moisture gradients. These findings emphasize the role of soil moisture as a hydrological driver of SOC dynamics in montado ecosystems and highlight the presence of persistent drought-prone hotspots. Remote sensing integration with field sampling provides a scalable approach to identify vulnerable areas. The study reinforces the need for long-term monitoring of moisture-carbon interactions to sustain montado resilience under climate change.

***Keywords*— Soil Moisture Index (SMI); Soil Carbon Stock; Moisture Regimes; Remote Sensing; Spatial Pattern**

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Geological and hydrological approach to surface Water Pollution in Inaouene Catchment Area

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ABSTRACT

The upper Inaouene waterched of approximately 1616 km^2 is a principal source of drinking and irrigation water for the Taza region and is subjected to extreme hydrological conditions (floods and low-flows). This study focuses on the effect of such extrêmes on the contamination of surface waters and surface sediments by trace metals, with respect to geological and morphometric controls. The methodology implemented here combines morphometric studies, geologic interpretations, the spatial analysis using GIS, and the measurements of trace metal content at monitoring stations scarttered on the oued network. This framework provides a means of evaluating the associations between geological materials, hydrololgical regims, and levels of metal contamination. The findings suggest that the heterogeneity of the geology toghether with morphometry of the watershed exert strong controls on the spatial variations of trace-metal contamination of the oueds. Floods favor erosion, sediment exchange and downstream transfer of metal-rich particles. Low-flows facilitate the build-up and accumulation of trace metals in isolated zones. The composition of the underlying geology exerts a contol on the level of metal contamination. By combining the above methodology with the small number of sampling stations, this research offers quantitative insights into the short-term impact of hydrological extrêmes on trace metals in oueds. It helps to deepen the understanding of the processes for sustainable water management in semi-arid regions.

***Keywords*— water pollution – hydrological regims – vulnerability - Inaouen- lithology- trace metal - GIS.**

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Sintering of Contaminated Dredged Harbor Sediments and Waste Glass into Artificial Aggregates: Densification Behavior and Heavy-Metal Stabilization

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ABSTRACT

The adoption of circular economy principles has driven growing interest in developing glass–ceramic materials from underutilized waste streams [1]. Dredged harbor sediment, an aluminosilicate-rich by-product frequently contaminated with heavy metals, poses both a significant environmental management challenge and a potential feedstock for the production of artificial aggregates [2,3]. This study investigates the conversion of contaminated dredged sediment into sintered glass–ceramic artificial aggregates by examining the influence of sintering temperature and glass addition on densification, pore development, and metal stabilization. Glass-assisted sintering promoted melt formation and pore closure, yielding dense aggregates at elevated temperature with compressive strength exceeding 20 MPa, low water absorption (<3%), and limited open porosity. Sequential extraction and leaching tests indicated that Cu, Zn, Cr, Pb, and Ni were retained in low-mobility residual fractions under acidic and marine conditions. Metal immobilization establishes environmental acceptability for reuse, while carbon analysis shows that production-related emissions (~0.45 kg CO_2 kg^{-1}) are partly compensated by avoided landfill and ocean disposal. Thermal processing thus shifts contaminated dredged sediment from a disposal burden to a functional glass–ceramic resource for sustainable sediment management in harbor systems [4,5]. This supports sintering as a circular-economy option that aligns material reuse with environmental risk reduction.

***Keywords*— Dredged sediments, Artificial aggregates, Metals Immobilization, Carbon footprint, Circular economy**

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Resolving sediment toxicity drivers in a contaminated harbor using bioavailability-adjusted risk quotients and bioassay-based assessment

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ABSTRACT

Marine sediments in harbors and estuaries accumulate potentially toxic elements (PTEs) and persistent organic pollutants (POPs) from industrial, urban, and maritime activities [1, 2]. However, sediment quality assessments based on bulk concentrations or guideline exceedances often fail to predict biological effects because sediment physicochemical properties strongly influence contaminant partitioning and bioavailability [3,4,5]. This study applies an integrated sediment toxicity assessment approach that combines *Artemia salina* bioassays with bioavailability-informed chemical risk quotients to improve the interpretation of contaminant-driven toxicity patterns in a complex harbor system. Surface sediments from Kaohsiung Harbor, Taiwan, were analyzed for PTEs, POPs, grain size, and total organic carbon. Acute sediment toxicity was evaluated using 48-h *A. salina* mortality based on sediment elutriates. Raw and physicochemically modified mean risk quotients (MRQs) were applied to distinguish bulk chemical risk from sediment property–mediated effects on contaminant partitioning. Bioavailability-adjusted PTE-based risk quotients showed the strongest association with 48-h *A. salina* mortality, outperforming raw chemical metrics. Physicochemically modified MRQ improved model parsimony and predictive performance relative to raw MRQ ($R^2 \approx 0.50$) without altering the inferred contaminant contribution pattern. In contrast, PAH-based and combined MRQs (PTEs + PAHs + DEHP) showed weaker explanatory power. Monte Carlo simulations indicated mortality distributions dominated by low-to-moderate effects, with <1% probability of extreme mortality, and clear spatial stratification across estuarine sediments and lower risk at harbor entrance stations. The integration of physicochemical parameters, bioassay responses, and statistical analysis clarified spatial patterns of sediment toxicity, distinguishing consistently impacted estuarine sediments from lower-risk harbor entrance areas.

***Keywords*— Artemia salina, Bioavailability, Sediment toxicity, Mean risk quotient, Probabilistic modelling**

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Comparison of an advanced oxidation and membrane process for humic acid degradation: Energy challenges and perspectives

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Introduction: Natural organic matter, especially humic acid (HA), is difficult to remove due to its complex, non-biodegradable nature and its tendency to cause membrane fouling.

This study compares electro-Fenton and membrane processes and evaluates their hybrid combination for sustainable humic acid removal.

Research question: This research aims to compare the removal efficiencies and energy consumption of (E-F) oxidation and membrane filtration for the treatment of (HA) contaminated water.

Methodology: The study adopts an (E-F) process in an undivided cell under constant current, acidic pH, and in situ generation of H_2O_2 for (HA) degradation. Membrane filtration experiments using nanofiltration (NF) and reverse osmosis (RO) were conducted to assess TOC and (HA) removal. Both processes were compared to evaluate their efficiency and performance in water treatment.

Results: Electro-Fenton TOC removal decreases with increasing (HA) concentration, following pseudo-first-order kinetics due to limited availability of •OH radicals. Simulation of surface water treatment shows that (NF) achieves over 80% TOC removal, effectively reducing (HA) even at high concentrations, while reverse osmosis membrane exceeds 95% TOC removal in (HA) rich waters.

Discussion: Electro-Fenton is effective for low TOC humic acid mineralization but its efficiency decreases at higher concentrations due to limited •OH radicals. Nanofiltration provides moderate removal (~80%) and is suitable for medium TOC levels, while reverse osmosis offers the highest efficiency (>95%) but with higher energy consumption and greater fouling risk, requiring pretreatment

Conclusion: Electro-Fenton is effective at low TOC but limited at higher levels. Nanofiltration offers moderate efficiency, while reverse osmosis achieves the highest removal. Hybrid electro-Fenton–membrane systems represent a promising and sustainable approach for (HA) removal.

***Keywords*— Humic acids, electro-Fenton, membrane processes, water treatment, fouling, sustainability.**

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A Fast Hybrid Modeling Approach for Design Optimization of Permanent Magnet Synchronous Machines with Nonlinear Magnetic Saturation Effects

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ABSTRACT
Introduction: Surface-mounted permanent magnet synchronous machines (SPMSMs) dominate high-performance applications (e.g., wind turbines, EVs) due to their high torque density and efficiency. Accurately predicting their air-gap magnetic field is essential for evaluating electromagnetic performance (average torque and back-electromotive force (EMF)) and parasitic effects (cogging torque and radial forces). However, deep nonlinear magnetic saturation in high-power SPMSMs challenges existing modeling techniques: analytical models neglect saturation, finite element analysis (FEA) is computationally expensive, and magnetic equivalent circuits (MEC) rely on restrictive geometric simplifications.
Research question: These limitations motivate the development of hybrid modeling techniques capable of balancing computational efficiency and physical accuracy. To address these challenges, this work aims to present and evaluate a novel hybrid semi-analytical modeling approach for the rapid and accurate electromagnetic analysis.
Methodology: The proposed method combines an analytical subdomain (SD) formulation, based on the solution of Poisson's and Laplace's equations in polar coordinates using harmonic series expansion, with a two-dimensional nonlinear MEC representing the stator teeth and yoke. The SD and MEC models are iteratively coupled through flux source injection and a local variable permeability scheme derived from nonlinear *B-H* material characteristics, ensuring magnetic field continuity at physical interfaces.
Results: This hybrid approach enables accurate modeling of magnetic saturation effects, which strongly influence torque production and cogging torque behavior. The results demonstrate rapid convergence and provide detailed insight into the harmonic content of the air-gap magnetic field. Validation against FEA shows excellent agreement while achieving a significant reduction in computational time.
Discussion: By effectively integrating these models, the framework resolves the computational challenges of conventional approaches. It provides a detailed understanding of how deep nonlinear magnetic saturation impacts machine performance, balancing the physical accuracy of FEA with the speed of analytical models.
Conclusion: Overall, the proposed hybrid SD–MEC framework offers a computationally efficient and accurate alternative to FEA for early-stage SPMSM design and optimization, making it well suited for high power wind turbines and electric vehicle applications.

***Keywords*— Electrical machines, exact subdomain (SD), flux sources, magnetic equivalent circuit (MEC), magnetic saturation**.

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Data Fusion of Low-Cost Sensor Networks and Dispersion Models for High-Resolution Urban Air Quality Mapping

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ABSTRACT

Climate change is expected to alter meteorological drivers of air pollution, influencing the formation, transport, and exposure patterns of key pollutants [1]. Low-cost sensor (LCS) networks provide the high-resolution, real-time data needed for risk management, but only when supported by robust calibration. Combining these sensors with dispersion models bridges spatial gaps, enhancing both exposure assessment and decision-making [2]. This study presents a high-resolution air-quality monitoring and mapping framework for the TÜBİTAK Gebze Campus, leveraging data from a pilot field study conducted between February and May 2024. The objective is to establish a localized dispersion model integrating real-time measurements from six LCSs using advanced spatial modeling techniques. The study used sensors to measure key pollutants, including nitrogen dioxide (NO_2), ozone (O_3), and fine particulate matter ($PM_{2.5}$), as well as critical meteorological parameters, including wind speed and direction, temperature, pressure, and humidity. LCSs developed in a previous study employ AI-based calibration to correct for environmental influences, with performance validated against CEN/TS 17660:1 standard through a year-long co-location study at four reference stations across different seasons [3, 4, 5]. Strategic sensor placement enabled the characterization of diverse micro-environments, from high-traffic gates to sensitive areas such as schools. Preliminary analysis showed that NO_2 peaks correlated with traffic hours, while O_3 and $PM_{2.5}$ levels were influenced by photochemical reactions and regional transport from the Gulf of Izmit. A Gaussian-based dispersion model specifically for NO_2, tailored to campus topography, was implemented to refine spatial accuracy. Model outputs and sensor data were integrated via data fusion to produce hourly, street-level maps. Results demonstrate that this integrated approach offers a robust, cost-effective solution for local air quality management.

Keywords — Low-cost sensor networks, air quality dispersion modeling, data fusion

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Enhanced Sono-Photocatalytic Degradation of Methyl Violet 10B over an Iron-Nitroprusside Complex Immobilized on Kaolin (FeNP@Kao) under Visible Light

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Introduction

The increasing discharge of persistent organic dyes from chemical industries into aquatic environments represents a serious environmental challenge. Therefore, the development of efficient and sustainable treatment technologies is essential. Among them, heterogeneous photocatalysis has emerged as a promising approach for the degradation of organic pollutants [1]. In this context, transition metal nitroprusside complexes have attracted attention due to their interesting optical and catalytic properties [2,3].

Research Question

This study investigates the efficiency of FeNP@Kao, an iron-nitroprusside complex immobilized on natural kaolin for enhanced stability [4], in the sono-photocatalytic degradation of methyl violet 10B in aqueous solution under visible light irradiation.

Methodology

FeNP@Kao was synthesized through an in situ reaction between Fe(II) ions and nitroprusside anions on the kaolin surface. The material was characterized using FTIR, XRD, SEM, BET, and UV–visible spectroscopy. To evaluate its catalytic performance, a series of experiments were conducted in a reactor assisted by ultrasonic irradiation. The optimization of the degradation process followed the One-Factor-At-A-Time (OFAT) strategy under the effect of four operating factors, including catalyst dosage, solution pH, H_2O_2 concentration and initial dye concentration.

Results

Characterization results confirmed the successful infiltration of the $Fe[Fe(CN)_5NO]$ complex onto kaolin, leading to a significant increase in the BET surface area from 32.8 $m^2.g^{-1}$ to 87.9 $m^2.g^{-1}$. UV–vis analysis revealed a narrow band gap of 2.18 eV, confirming the material's efficiency under visible light [5]. The optimum conditions determined at room temperature were $C_{MV10B} = 15$ mg.L^{-1}, $m_{FeNP@K} = 1$ g.L^{-1}, $C_{H2O2} = 0.060$ mol.L^{-1}, and pH = 3 with a total removal efficiency (100%) achieved after 60 min of reaction.

Discussion

The catalyst's narrow band gap allows for efficient activation under visible light irradiation. Ultrasonic assistance was found to be crucial, increasing the degradation yield from 45% to 80% compared to systems without ultrasound.

Conclusion

the development of FeNP@Kao offers a high-performance and cost-effective photocatalyst for wastewater treatment. By combining the optical properties of nitroprusside complexes with the stability of natural kaolin.

***Keywords*— Heterogeneous photocatalysis, Iron-nitroprusside, Kaolin, Sono-photodegradation, Methyl violet 10B, Visible light.**

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Heat Transition and Decarbonization in the German Building Stock: Insights on Energy Vulnerabilities in Northern Germany

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ABSTRACT

Achieving climate neutrality by 2045 requires a fundamental transformation of the German building sector, where residential heating accounts for over 65% of final energy consumption and remains largely fossil-based. Despite increasing regulatory pressure, renovation rates remain insufficient to meet decarbonization targets. While existing research mainly focuses on technical solutions, spatial and socio-economic dimensions are often underrepresented. This paper develops a spatially explicit and socio-technical framework to analyse urban heat transition pathways using a representative district in Braunschweig as a case study. Building-level energy demand, renewable energy potentials, and greenhouse gas emissions are modelled through scenario-based simulations. The analysed pathways include heat pump deployment, district heating, photovoltaic integration, and building retrofit measures. In addition to technical performance, socio-economic indicators such as income distribution and tenancy ratios are integrated. This enables the identification of spatial patterns of energy vulnerability and the assessment of distributional impacts. The results show that post-war building typologies are the main drivers of emissions and that electrification combined with renewable integration achieves the highest reduction potential. At the same time, socially vulnerable groups are disproportionately affected by energy price volatility and face limited capacity to invest in decarbonization measures. The findings highlight that effective heat transition strategies must integrate technical, spatial, and social dimensions to ensure both environmental effectiveness and social equity.

***Keywords*—Decarbonization, Heat Transition, Building Energy Modeling, Energy Vulnerability, Residential Building Typologies**

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Instrumentation and Equipment for a High-Power PEM Module Fuel Cell Test Bench

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ABSTRACT

PEM fuel cells are a technology that enables the generation and cogeneration of clean energy, with high efficiency and autonomy. Test benches are designed and manufactured to evaluate their functionality, performance, reliability, and efficiency; these are generally designed to test PEM fuel cells at the stack level. Nevertheless, testing of high-power PEM fuel cell modules has become increasingly important due to their growing use in the transport, industrial and residential sectors. Test benches for high-power PEM fuel cell modules require a flexible and modular design, since the PEM module operates as a “black box” into which various equipment and instrumentation are integrated, provided to the requirements of technical safety and the ATEX directive. The aim of this work is to define the measurement instrumentation, final control elements, and auxiliary components required for a test bench. The selection is based on the architecture of the PEM fuel cell subsystems, ensuring the supply of hydrogen and air at the required pressure, thermal management of the heat generated by the fuel cell, electrical and electronic interconnections, and the configuration of a monitoring and control system. The instrumentation and equipment are detailed below:

1. Hydrogen and air supply line requires installing temperature, pressure, and flow transmitters, as well as regulators, valves, pressure gauges, and filters. When selecting this equipment, it is essential to identify the ATEX zone in which it will be installed.
2. The cooling system is usually supplied by the manufacturer; however, if one is not available, a high-power fan may be used. In addition, mass flow meters, pressure transmitters and temperature transmitters must be installed to calculate the heat dissipation.
3. The power electronics system requires a bidirectional load to generate the initial power supply to the fuel cell's BoP (Balance of Plant) during the start-up phase and to dissipate the energy generated by the fuel cell. If the bidirectional load does not have enough power, a resistor bank can be added to dissipate the excess energy. Additionally, an electrical panel must be designed to include the protections and connections for the sensors, actuators, supply voltage, PLC and isolation monitor used in the control of the test bench.
4. Supervisory Control and Data Acquisition (SCADA) system depends on the design engineer’s preferences; LabVIEW or other software may be used, provided it ensures interoperability between the subsystems.

In conclusion, the equipment and instrumentation for a high-power fuel cell test bench are selected by considering each of the subsystems of a PEM fuel cell, to ensure the simulation, control, and analysis of the fuel cell's complete operation and to perform polarization curve, efficiency analysis, and fault diagnosis.

***Keywords*— Instrumentation and equipment, Test bench, High Power PEM Module Fuel Cell, Testing**

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Agriculture, Environmental Biotechnology, and Water Systems under Climate Change: A Global Qualitative Assessment of Economic Growth and Sustainability Outcomes

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ABSTRACT

Introduction: Rising global temperatures, persistent water scarcity, and soil degradation are placing unprecedented strain on agricultural systems and economic growth. While environmental biotechnology and improved water management offer promising responses, the qualitative links between these technologies, financial mechanisms, and policy environments remain insufficiently understood.

Research Question: This study asks: how do agricultural biotechnology and water management technologies interact with financial systems and institutional policies to shape sustainable economic outcomes under climate stress?

Methodology: Qualitative review using the PRISMA approach of 150 sources. Thematic coding, mapping and matrix analysis was done using NVivo 2026.

Results: "Resilience" and "adaptation" were better than "yield/profit" and "adaptive water systems" were core connectors. Regional inequality: low-capital solutions are successful in areas where resources are limited while high-capital projects are languishing. Financial flexibility is highly related to the success of getting a biotech to market ($r = 0.82$).

Discussion: Low capital, decentralized systems overcome rigid systems' advantages, "Resilience Paradox" offers a challenge. The result of modulations is an endogenous strategic outcome of Resilience.

Conclusions: Make resilience-weighted monitoring and coordinated policies for innovation financing. Climate Resilience is an economic pillar of agriculture and water systems.

***Keywords*— Agriculture; Environmental Biotechnology; Water Systems; Climate Change; Economic Growth; Sustainability Outcomes; Qualitative Analysis; NVivo.**

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Climate, Soil, and Plant Community effect on Early-Stage Litter Decomposition at Regional Scale in Bulgaria

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ABSTRACT

Litter decomposition represents one of the largest fluxes in the global terrestrial carbon cycle and a number of large-scale decomposition experiments have been conducted focusing on this fundamental soil process. Early stage litter decomposition rates are primarily controlled by three main factors: litter quality (chemical composition), followed by regional climate (temperature and moisture) and soil conditions. In temperate, Mediterranean-influenced regions like Bulgaria, warmer temperatures and higher humidity accelerate decay, with decomposition generally being faster in forests with higher quality, nitrogen-rich litter.

In this study we tested the effect of climate, litter type and land-use on early stage decomposition (3 months and 1 year) across seven ecosystems under TeaComposition initiative. The studied sites represent different type of land use (natural forests, grassland and urban ecosystems) in 3 regions: Central Balkan Mountain, Rila Mt and Sofia city. We applied a standardized protocol of the TeaComposition initiative using tea bags as a standardized metric for decomposition as proposed by Keuskamp et al. (2013) and adapted to match global and long-term applications.

Land use affects significantly tea mass remaining after 3 months of field incubation, especially expressed between Spruce natural mountain forest and natural mountain grassland (Rooiboss tea bags). The strong effect of litter quality on early stage litter decomposition was observed for Beech and Spruce natural mountain forests. For Green tea bags differences were obtained for urban forest and urban grassland in Sofia city, which suggests for litter quality effect. For urban and natural grasslands the difference was also significant and is an evidence for climate effect on litter decomposition.

Our study revealed that land use has the most significant effect on early stage decomposition rate. The effect of litter quality was observed for beech and spruce natural mountain forests as well as for urban forest and urban grassland site. Decomposition rates were higher in warmer and more humid climate except in beech natural forest. It could be explained by different climate effect on the decomposition depending on different litter characteristics (plant community effect).

***Keywords*— land-use, litter quality, climate effect, decomposition rate, forest ecosystems**

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Calculation of High-Viscosity Oil Temperature During Pipeline Operation and Shutdown

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ABSTRACT

The transportation of high-viscosity and waxy crude oils through long-distance pipelines presents significant thermal and hydraulic challenges, especially under hot pumping conditions with temporary shutdowns. During operation, oil is heated to reduce viscosity and maintain flow. However, when pumping stops, the oil cools due to heat exchange with surrounding soil, leading to increased viscosity, higher restart pressures, and possible flow blockage from wax crystallization. Therefore, accurate prediction of temperature behavior under both steady-state and transient conditions is essential for safe operation.This study evaluates the accuracy of predicting temperature evolution during operation and shutdown, and its application in estimating safe shutdown durations. The analysis focuses on the Severnye Buzachi–Karazhanbas pipeline in Kazakhstan (length 25 km, diameter 0.414 m), operating with inlet temperatures around 60 °C. A one-dimensional heat transfer model is applied due to the large length-to-diameter ratio. The classical Shukhov formula is used for steady-state conditions, while a modified approach describes transient cooling, accounting for heat exchange between oil, pipe, insulation, and soil.

The model incorporates variable heat transfer coefficients, temperature-dependent viscosity, and phase change effects using the apparent heat capacity method. Validation with SCADA data (2020–2024) shows strong agreement: steady-state deviation does not exceed 0.002 °C, while shutdown deviations range from 0.29 to 0.44 °C over 18 hours. Results indicate that soil thermal conductivity strongly influences cooling rates, while latent heat improves prediction accuracy. The proposed approach enables reliable estimation of safe shutdown durations and supports improved thermal management of pipeline systems.

***Keywords*— non-isothermal flow, waxy oil, pump shutdown, safe shutdown time.**

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