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EDITORIAL

Renewables and the environment: a digital–green nexus

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Introduction

Energy and water are common inter-related pillars for economic growth and social development. The sustainability of both resources became a must in order to achieve development synergies to overcome the challenges of climate change and food security which are exacerbated by population growth and urbanization which create a dynamic baseline against which to address service access (Masoud 2020).

To achieve carbon neutrality targets, renewable energy development strategies should be formulated to provide sufficient development impetus for the energy transition. This special issue explores the latest practices from selected current projects devoted to the development and use of advanced and enhanced materials and implement techniques for the renewable energy harvesting, storage, and conversion supporting a greener environment. Furthermore, access to safe water, sanitation, and hygiene is the most basic human need for health and well-being. The 6th Sustainable Development Goal (SDG), established by the United Nations General Assembly in 2015: Clean Water & Sanitation, is to ensure availability and management of water and sanitation for all, towards realizing a cleaner environment. To reach universal access to drinking water, sanitation, and hygiene by 2030, the current rates of progress would need to increase fourfold. Achieving these targets would save 829,000 people annually, who die from diseases directly attributable to unsafe water, inadequate sanitation and poor hygiene practices (source: https://www.un.org/sustainabledevelopment/water-and-sanitation/). Some selected techniques are presented for wastewater decontamination.

Developmental practices based on sound scientific techniques with case studies are seen to enrich policy-makers knowledge to sustain the environment and natural resources. With these goals, the issue provides us and the ESPR readers a potent source of knowledge on the overarching inter-related issues of the renewable energy and the environment, along with the values their integrated theme brings to the nations. It also expands our knowledge on practices carried out to reach the overarching goal of the net-zero emission by 2050 in a digital–green nexus of renewables and climate changes. This is to properly and efficiently enable effective decision-making to adapt and mitigate climate changes and to discover new techniques for assessing renewable energies. The issue assigned an abbreviation "RedGN" gathers research works from current projects devoted to enhancing the preparedness for a smart green-digital environment with lowest net-zero emissions. The research results presented in a compelling manner on novel technologies and applications of the renewable energy and wastewater decontamination covering issues of enhancing (1) *engine efficiency and emission reduction*, (2) *energy storage by developing new novel nano-fibers*, (3) *energy harvesting and conversion*, (4) *and advanced wastewater decontamination technologies*. This special issue cannot fully reflect the diversity and creativity of the ideas and the new insights presented in all articles. However, as editor of this special issue, I hope that this issue may prompt scientists from the diverse fields to participate in the upcoming issues to help solve problems related to the renewables towards establishing a smart green environment.

Results and discussion

Net-zero emissions by enhancing engine efficiency

Towards the net-zero emissions leading to greener environment by enhancing engine efficiency and fuel combustion properties, Elbanna et al. (2022) have evaluated, at different premixed charge ratios, the engine vibrations, pollution, efficiency, and combustion properties of a premixed charge compression ignition (PCCI) diesel–fueled engine. Engine knocking and intense vibrations are used to evaluate the PCCI operation. Results clarified that the PCCI injection strategies affect greatly the combustion phasing, where the equivalence ratio stratification potentially reduces

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nitrogen oxide (NO_X) pollutants significantly. The results also demonstrated that partial premixing has an inherent trade-off between NO_X emissions and unproductive combustion products (carbon monoxide (CO) and unburned hydrocarbons (UHCs)). Also demonstrated were the slight reductions in combustion efficiency (CE) caused by incomplete combustion and non-optimized spontaneous ignition of the premixed charge. Finally, the controllable operation could be achieved using an efficient closed control system.

Nanofibers for renewable energy storage

Developing new nanofiber thin film composite promising for renewable energy storage applications has been introduced in this issue by Kenawy et al. (2022). The new nanofiber thin film composite is fabricated in the form of $[P(An\text{-}MMa)/ZrO_2]^{TF}$ at average crystallite size of 171.04 nm of tightly packed fibrous nanowires or brushes arranged in one-dimensional morphological structure yielding large optical energy bandgap vital for the renewable energy storage applications. The composite is made up of poly(acrylonitrile-co-methyl methacrylate) (P(An-MMa)) with zirconium dioxide (ZrO_2) synthesized using the sol–gel method and subsequently converted to a thin film via the physical vapor deposition (PVD) technique. Several characterization techniques (e.g., Raman spectroscopy, X-ray diffraction (XRD), thermogravimetric analysis (TGA), scanning electron microscopy (SEM), and ultraviolet–visible (UV–Vis) optical spectroscopy) are applied for the developed thin film material where its molecular structure is validated with accurate match against time-dependent density functional theory (TD-DFT/DMol^3) and Cambridge Serial Total Energy Bundle (TD-DFT/CASTEP).

Enhancing renewable energy harvesting and conversion

The thermal performance enhancement of the wick-type solar still using titanium dioxide nanoparticles embedded in paraffin wax as a phase change material (PCM) is addressed in Ibrahim et al. (2022). Two solar stills were created, one of which used PCM in its pure form and the other of which used PCM combined with TiO_2 nanoparticles. By increasing the PCM's thermal conductivity through the application of nanoparticles, the examined solar still's output and efficiency were increased. Jute and cotton were used as the wick materials to test the proposed concept. The results showed that the PCM's thermal conductivity rose by 9.6% as a result of the nanoparticle addition. Furthermore, it was discovered that when the PCM-nanocomposite was present, the daily productivity for cotton and jute was 1058 and 1226 ml/m^2 day, respectively.

The renewable energy conversion is greatly affected by the efficiency of the harvesting materials and the working conditions (climate, cleaning/cooling, etc.). Operating temperature over 25 °C significantly degrades the electrical efficiency of the photovoltaic (PV) system. Ibrahim et al. (2023), investigated the cooling effect of Al_2O_3 nanofluid concentrates on the electrical and thermal properties of polycrystalline solar panels in outdoor conditions. With active nanofluid cooling, the surface operating temperature of the PV module dropped significantly to about 22.83%. The authors recommended the use of more thermally conductive nanofluids with narrowing the spaces between the cooling pipes in the back of the PV module to improve the cooling process and efficiency.

Decontamination of wastewater

The world's population is ever-increasing, and water resources are limited in the Earth's environment. Therefore, clean water resources are a critical issue for humans. Agricultural wastes, industrial sewages, and urban effluents are typical water resources in nature that need to be purified. There are several kinds of wastewater pollutants, including heavy metals, toxic ions, bacteria, fungus, toxic dyes, oil compounds, phenolic compounds, and nitro-organic compounds, which have adverse effects on the environment. Heavy and toxic metals enter the human body through the food chain and are non-degradable in the environment. In recent years, advanced materials, nanoadsorbents, and nanocatalysts have become among the most important materials for the removal of contaminants from effluents that have many benefits, including low-cost, high efficiency, easy synthesis, and process simplicity. Also, nanoadsorbents have high porosity, high specific surface area, and low surface-to-volume ratio compared to conventional adsorbents.

In this issue, El-Ghobashy et al. (2023) carried out wastewater decontamination through effective low-cost Cu(II)-loaded Amberlite IR-120 (R-Cu^{2+}) for the removal of ammonia, novel synthesized cross-linked chitosan *bis*-aldehyde Schiff base derivatives for the effective removal of U(VI) as described by Hamed et al. (2022), nanoferrite composite of spinel cadmium–copper as magnetic catalysts for decontamination is presented by Mangood et al. (2023), and the green synthesis of zinc(II) metal–organic framework (Zn-MOF) developed in Elsherbiny et al.

(2023) that was tested for the adsorption of two anionic dyes (aniline blue (AB), and orange II (O(II)) and cationic dye (methylene blue (MB)) from aqueous solution. The research complements the business case development model of "solid waste to value-added MOFs."

Advanced material of Cu(II)-loaded Amberlite IR-120 (R-Cu^{2+}) is developed and compared to loads of Co^{2+} and Ni^{2+} cations for the removal efficiency of ammonia from aqueous solution by El-Ghobashy et al. (2023). The R-Cu^{2+} is characterized applying various FT-IR, TGA, SEM, and EDX techniques. The adsorption at 200 mg/g, pH = 8.6, and 303 K within 60 min using 0.1 g R-Cu^{2+} and an initial concentration of ammonia of 1060 mg/L, was an endothermic and spontaneous for the ammonia onto R-Cu^{2+} achieving the highest removal percentage and obeying the non-linear plot of both Freundlich and Langmuir isotherms. The resulting product (R-Cu(II)-amine composite) exhibited high catalytic activity and could be low-cost material for the elimination of dyes such as aniline blue (AB), methyl green (MG), and methyl violet 2B (MV2B) from wastewater.

Hamed et al. (2022) developed new three novel diversified synthesized cross-linked chitosan *bis*-aldehyde Schiff base derivatives for the effective removal of U(VI) with adsorption capacity in level range of 142–114 mg/g from aqueous solutions. Thermodynamic, structure, and optical characterization techniques of FTIR, ^{1}H NMR, XRD, and TGA techniques are applied to differentiate the potential of the three derivatives. The thermodynamic analyses confirm the exothermic nature and the spontaneity of the adsorption process.

Mangood et al. (2023) developed nanoferrites composite of spinel cadmium–copper and used them as magnetic catalysts for promoting wastewater decontamination with special focus devoted to addressing the impact of Ag ions doping and their influence on the structural, magnetic, and catalytic characteristics of the spinel nanoparticles, as well as on their morphology. The developed nanoparticles proved promising, efficient, and stable materials for Fenton-based alkaline wastewater treatment.

Organic dyes are widely utilized in plastics, cosmetics, textiles, paper, and prescribed drug industries (Beydaghdari et al. 2022a). These dyes pollute the environment and cause serious air, water, and soil contamination and pose many health problems (Beydaghdari et al. 2022a, b). Therefore, sewer water ought to be effectively treated before discharge into the natural environment. In this issue, green synthesis of zinc(II) metal–organic framework (Zn-MOF) has been carried out by Elsherbiny et al. Such MOF attains large porosity, high surface area, potentially high density of active sites, and acceptable thermal and chemical stability (Beydaghdari et al. 2022a; Singh et al. 2022). The prepared Zn-MOF contains Zn metal extracted from the spent Zn batteries and commercial terephthalic acid as a linker. Characterization techniques of X-ray diffraction (XRD), Fourier transform infrared (FT-IR), scanning electron microscopy–energy-dispersive X-ray spectroscopy (SEM–EDX), nitrogen adsorption at 77 K, and transmission electron microscope (TEM) are applied to better understand the physicochemical properties of the as-prepared Zn-MOF where its structure was compared to the available commercial product. Moreover, the efficiency and the selectivity of the prepared Zn-MOF towards the removal of three dyes, namely, aniline blue (AB), acid orange II (O (II)), and methylene blue (MB) from aqueous solutions, were understood.

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