Index No.: 17/22/Chem./27

Title: Development of Agro and Industrial Waste Based Nano-adsorbents for Decontamination of Water

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Long-term hazards to life are posed by environmental pollution, including contamination of water and soil, which is mostly brought on by industrial and agricultural activities. Among different methods, adsorption and photocatalytic degradation have been found to be effective and affordable processing routes to remove various pollutants from water. The present work demonstrates the synthesis of porous adsorbent and photocatalyst materials for effective removal of contaminants like Fluoride, Arsenic(V) and Methylene Blue (MB) dye by means of adsorption and photocatalytic degradation processes.

Zeolite based magnesia (MgO) and alumina (Al_2O_3) composites were synthesized using rice husk ash (agro waste) as silica source and precursor metal salts following wet chemical processing. BET surface area values of MgO and Al_2O_3 modified Zeolite were found to be 69 and 257 m^2/gm, respectively. The prepared composites were utilized for removal of fluoride ions from water. The effects of contact time, temperature, pH, competing ions, sample dose, initial fluoride concentration and recyclability test were performed. The MgO modified zeolite exhibited 94% removal whereas the Al_2O_3 modified zeolite showed 99% removal of fluoride ions within 90 mins. A tentative mechanism for the adsorption of fluoride from aqueous solution by the synthesized Zeolite composite was proposed.

The work was published in (a) Trans.Ind.Ceram.Soc.2021, 80(3), 199-207 and (b) Mater.Adv.2022,3,8544-8556.

Iron oxide (α-Fe_2O_3) based adsorbent materials utilizing industrial waste red mud were synthesized by hydrothermal process in the presence of NH_4OH.The synthesized particles reveal BET surface area in the range of 136-347 m^2/gm. The product was used for the removal of As(V) from water. The maximum As(V) adsorption capacity of 32-41 mg/gm was obtained for adsorbent dose of 0.25 gm/L. The arsenic level could be lowered down to 2-3 µg/L (<10 µg/L as per WHO's limit) with contaminated real water (64 µg/L) using 0.25 gm/L of sample dose within 5 min of adsorption.

The work was published in ACS Omega.2023,8, 29281-29292.

Metal (Mn, Cu, Ce) doped and undoped iron oxide-based photocatalysts derived from red mud present a viable, environmentally acceptable way to effectively remove methylene blue (MB) dye from water. The crystallinity of pure α-Fe_2O_3 (hematite) phase was confirmed by XRD, while the binding energy of metal ions in α-Fe_2O_3 matrix were ascertained by XPS analysis. The 3 wt% Cu doped iron oxide with a TOC value of ~84.7% showed the best removal efficacy of MB to the tune of ~91%within 60 min of visible light irradiation. Based on scavenging tests, electrons and hydroxyl radicals (•OH) have been shown to be the major players in the photo degradation of pollutants.

The work was published in New J. Chem.2024,48, 10401-10414.

Therefore, using agro and industrial wastes for the synthesis of suitable adsorbent materials for water decontamination holds significant promise in mitigating environmental pollution. By repurposing waste materials, water pollution issues were addressed with a sustainable resource management and environmental preservation as well.

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