Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.25745

Sustainable Nanocomposite Design: Fungal-Synthesized Iron Biochar/Zn-MOF-74 for Efficient Chromium and Nanoplastic Removal

DR. SHOUVIK MAHANTY[1] AND DR. GOPALA KRISHNA DARBHA, PHD[2]

[1]Indian Institute of Science Education and Research Kolkata
[2]Indian Institute of Science Education and Research Kolkata

This study explores the synthesis and application of fungal-synthesized iron oxide nanoparticles (IO-NPs) and an iron biochar/Zn-MOF-74 composite (IO-Biochar/Zn-MOF-74) for the effective removal of chromium (Cr) ions and nanoplastics (NPs) from contaminated aqueous environments. The IO-NPs were synthesized via a green approach using *Corynespora cassiicola* – CNMP1, isolated from the Indian Sundarbans, and subsequently incorporated into biochar derived from sugarcane husk before integration with Zn-MOF-74. Characterization techniques, including Transmission Electron Microscopy (TEM) and X-ray diffraction (XRD), confirmed the nanoscale structure (20–60 nm), spherical morphology, and superparamagnetic properties of IO-NPs and IO-Biochar/Zn-MOF-74. The IO-Biochar/Zn-MOF-74 composite exhibited a high surface area and hierarchical porosity, enhancing its adsorption performance in comparison to IO-NPs. Batch adsorption experiments demonstrated the superior efficacy of IO-Biochar/Zn-MOF-74, achieving equilibrium adsorption capacities (*qe*) of 258.33 mg/g for Cr ions and 212.32 mg/g for NPs under optimized conditions (pH 6.8, temperature 35°C, adsorbent concentration 100 mg/L, and contact time 120 minutes). Adsorption data followed the Langmuir isotherm model, indicating a monolayer adsorption mechanism, with maximum adsorption capacities (*Qmax*) exceeding 498 mg/g for Cr ions and 304 mg/g for NPs. Advanced computational modelling using Response Surface Methodology (RSM) and Artificial Neural Networks (ANN) optimized the adsorption process, revealing optimal conditions of 99.12 mg/L for IO-Biochar/Zn-MOF-74, pH 7.0, and temperature at 35°C, which were experimentally validated with removal efficiencies of 98.19% for Cr ions and 99.22% for NPs. Field applicability was assessed using groundwater samples from a site near Chromite Ore Processing Residue (COPR), spiked with 20 mg/L NPs. Treatment with 100 mg/L of IO-Biochar/Zn-MOF-74 at pH 7.2 and 313 K resulted in 98.29% removal of both Cr and NPs within 120 minutes. This study highlights the potential of fungal-synthesized IO-NPs incorporated into biochar-based MOF composites for scalable water remediation, offering an eco-friendly and highly efficient solution for emerging contaminant removal.