Utilization of Nanocomposites in Environmental Pollution Cleanup

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Thematic Area: Materials & the Environment

Abstract

Environmental pollution, driven by industrialization, urban expansion, and intensified agricultural practices, poses a significant threat to ecosystems and human health worldwide [1,2]. Conventional remediation approaches, such as chemical precipitation, adsorption using traditional materials, and biological treatments, often fail to achieve complete removal of complex contaminants [3,4]. Nanotechnology-based materials, particularly nanocomposites, offer a promising alternative due to their tunable physicochemical properties, multifunctionality, and high surface reactivity [5,6]. This study investigates the synthesis, characterization, and environmental application of nanocomposites for mitigating pollutants, including heavy metals, pesticides, dyes, pharmaceuticals, and antibiotic residues. Nanocomposites were synthesized using controlled chemical methods, characterized for surface area, functional group density, and magnetic responsiveness, and their performance was evaluated through adsorption, catalytic degradation, and recovery experiments under laboratory-simulated environmental conditions [7,8]. Results indicate that nanocomposites significantly enhance contaminant removal efficiency compared to conventional methods while maintaining high stability, recyclability, and regeneration potential over multiple cycles [5,9]. Ecotoxicological assessments suggest that, although generally effective, potential risks such as nanoparticle leaching and bioaccumulation require careful management through surface functionalization, environmentally friendly synthesis, and adherence to regulatory frameworks [4,10,11]. Overall, these findings highlight nanocomposites as a multifunctional, high-performance, and environmentally promising approach for pollutant remediation, bridging the gap between laboratory research and practical, large-scale environmental applications, while emphasizing the need for interdisciplinary research to balance efficacy, safety, and cost-effectiveness in future implementations [1,2].

Keywords: environmental pollution, nanocomposites, heavy metals, water remediation, sediment treatment, toxicology

Acknowledgements: Please include acknowledgements, including funding sources.

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