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SUSTAINABLE USE OF SOME NATURAL MATERIALS AND WASTE FOR THE DECONTAMINATION OF ENVIRONMENTAL COMPONENTS POLLUTED WITH HEAVY METALS

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Abstract

The increasing prevalence of heavy metal pollution in various environmental components presents a critical challenge to global sustainability. This review synthesizes recent advancements in the sustainable use of natural and waste-derived materials for the environmental decontamination, focusing on cost-effective, eco-friendly, and versatile adsorbents. It contrasts conventional remediation methods, which are often expensive, resource-intensive, and environmentally taxing, with innovative alternatives that utilize agricultural residues, industrial by-products, and marine-based materials. Key materials discussed include clays, zeolites, biochar, chitosan, and agricultural waste such as fruit peels and rice husks, each of which exhibits unique adsorption capabilities due to properties like high cation exchange capacity and surface functionalization.

The review further explores composite materials that combine these natural adsorbents with nanoparticles, enhancing their effectiveness in removing diverse pollutants through mechanisms like ion exchange, complexation, and electrostatic attraction. Advances in chemical, thermal, and physical modification techniques are also highlighted for their ability to improve adsorption efficiency, making these materials more adaptable to complex contamination scenarios. Sustainable materials such as peat moss and algae-based sorbents are shown to be particularly valuable in decentralized and rural applications, where conventional approaches may be impractical or prohibitively expensive.

The environmental and economic benefits of using natural and waste-derived materials, including lower greenhouse gas emissions, biodegradability, and alignment with circular economy principles, are emphasized. These materials offer promising potential for achieving stringent environmental standards and improving ecosystem resilience against heavy metal contamination. By bridging the gap between sustainable material science and environmental remediation, this study underscores the role of renewable, low-cost sorbents in the future of pollution management and environmental restoration.

Key words: sustainable remediation, heavy metal decontamination, natural adsorbents, waste-derived materials, environmental pollution control

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