

Chapter 5

Hydrophytes as a Sustainable Tool for Bioremediation of Heavy Metals in Wetland Ecosystems


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ABSTRACT

Wetlands are essential for preserving biodiversity, ecological balance, and water quality. Increasing human activity has resulted in serious heavy metal contamination from several avenues. They are hazardous, persistent, and bioaccumulative, pose major threats to the environment and human. Bypassing expensive conventional remediation approaches, natural hydrophyte-based phytoremediation absorb, stabilize, or transform pollutants, provides a sustainable and economical substitute. Their

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heavy metal uptake and detoxification capabilities are done by root systems, high biomass, and symbiotic relationships with rhizospheric microorganisms. Challenges, include seasonal growth fluctuations, invasive potential, metal saturation, and safe biomass disposal, despite benefits like cheap operating costs, biodiversity support, and biomass valorization. In accordance with sustainable development objectives, hydrophyte-based remediation provides an effective strategy to restore polluted wetlands, fostering ecological resilience.

INTRODUCTION

Wetland habitats are dynamic, critical and versatile ecosystems that exist at the land-water interface, comprising a wide range of ecological territory encompassing marshes, swamps, bogs, and fens (Mitsch et al., 2015). Often referred to as the “kidneys of the earth,” these areas remain saturated throughout the year, generating unique lives that sustain both water and terrestrial habitats. Wetlands are far from being wastelands, as they provide enormous ecological benefit. They act as natural water filters, trapping pollutants and sediments, as well as essential sponges that absorb excess rainfall, reducing flooding, nurturing biodiversity and replenishing groundwater resources (Alikhani et al., 2021; Wu et al., 2023). Furthermore, they are among the world's most biologically productive ecosystems, providing critical breeding and rearing grounds for several species of fish, birds, amphibians, and invertebrates. Despite their critical roles in biodiversity, water purification, and climate regulation, wetland habitats are among the most vulnerable in the world, inflicted with diverge contaminants, especially heavy metals. Escalating anthropogenic activities like mining, urbanization, agricultural runoff, and industrial discharges release Heavy metals (HM) like Lead (Pb), Cadmium (Cd), Mercury (Hg), Arsenic (As), and Chromium (Cr) in the system (Li et al., 2022).

Heavy metals do not disintegrate over a stretch, in contrast to organic pollutants; instead, they carry on in the different water sources like surface or ground water, thereafter accumulating in in the sediments that sustain aquatic life. HM impose severe toxicity, reproductive failure, and mortality to the existing flora and fauna population of wetland inclusion of human lives. Interestingly, these metals have the ability to get biomagnified as they move high in the food chain, and place top predators like fish-eating birds and mammals at risk. The most upsetting part is that the wetland's natural filtering capacity is burdened with entrapped organics, heavy metals, creating a long-term pool of contaminants (Ali & Khan, 2019).

Numerous efficient traditional techniques are applied for heavy metal removal which includes chemical precipitation, ion exchange, activated carbon induced adsorption and electrochemical methods. Traditional methods are efficacious, but they

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