Chapter 3
The Role of Microbial Communities in Hydrophyte-Assisted Bioremediation

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ABSTRACT

Hydrophyte-assisted bioremediation is a prospective green technology for extenuating water pollution, particularly in raised wetlands and other aquatic treatment systems. The microbial populations linked to hydrophytes, particularly in the rhizosphere, are primarily responsible for this approach. Root exudates from hydrophytes not only shape microbial community composition but also enhance microbial activity, leading to increased rates of processes such as nitrification, denitrification, sulphate reduction and organic matter decomposition. In return, microbes support plant health. This chapter provides an in-depth overview of the functional roles and ecological dynamics of microbial communities in hydrophyte-based remediation systems. It also

DOI: 10.4018/979-8-3373-4037-1.ch003

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explores current advances in microbial community profiling, such as metagenomics and transcriptomics, which offer new insights into the plant–microbe interactions underpinning these systems. Understanding these symbiotic relationships is key to designing, low-cost, and sustainable treatment technologies for contaminated aquatic environments.

INTRODUCTION

Aquatic pollution from industrial discharge, agricultural runoff, and domestic sewage poses severe threats to freshwater ecosystems. One of the primary contributors of pollution in the soil and aquatic environment is pollution from various industrial activities. The manufacturing process releases various kinds and levels of heavy metals. Pesticides, fertilizers, and pesticides used in agriculture emit contaminants released into the environment, including lead, arsenic, copper, zinc, nickel, and aluminum (Ayilara & Babalola 2023). Heavy metal-containing waste is inappropriately dumped into aquatic and soil ecosystems which results in chronic diseases among humans as well as livestock. Therefore, these contaminants must be treated using physical, chemical, or biological methods. Physical and chemical procedures have been used for several decades, but they have limitations. Chemical bioremediation requires specific tools and proficiency, while physical bioremediation is affluent (Bakhshoodeh et al., 2020). Plants stimulate physicochemical and biological processes which aid in purify wastewater by eliminating metals from its effluents (DalCorso et al., 2019). Hydrophytes, such as *Eichhornia crassipes*, *Pistia stratiotes*, *Lemna gibba* and *Phragmites australis* are capable of up taking, stabilizing, or transforming pollutants. According to Ayaz et al. (2020), other emergent species classes, such Typha latifolia, can also absorb metals at higher concentrations in their roots and shoots. Because they are ecologically adapted, regional hydrophyte species can be used in artificial wetlands for wastewater treatment, according to a 2009 study by Khan et al. Utilizing biological organisms to transform potentially hazardous contaminants into innocuous substances, bioremediation is therefore one of the most efficient and cost-effective alternatives to conventional approaches (Akhtar et al., 2020). Both plants and microorganisms can be used in biological remediation; hydrophyte-assisted bioremediation, sometimes referred to as engineered wetlands or phytoremediation in aquatic systems, provides a sustainable and environmentally beneficial approach. Rhizospheric and endophytic microbial communities, which are essential for biogeochemical cycling and pollutant degradation, significantly enhance the remediation efficiency of hydrophytes. Through this approach, the microbial communities may enhance the water's quality by eliminating organic carbon, nitrogen, phosphorus, suspended particles, heavy metals, phenols, COD, and BOD.

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