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REVIEW ARTICLE

Microbial and plant-assisted heavy metal remediation in aquatic ecosystems: a comprehensive review

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Abstract

Heavy metal (HM) pollution in aquatic ecosystems has an adverse effect on both aquatic life forms as well as terrestrial living beings, including humans. Since HMs are recalcitrant, they accumulate in the environment and are subsequently biomagnified through the food chain. Conventional physical and chemical methods used to remove the HMs from aquatic habitats are usually expensive, slow, non-environment friendly, and mostly inefficient. On the contrary, phytoremediation and microbe-assisted remediation technologies have attracted immense attention in recent years and offer a better solution to the problem. These newly emerged remediation technologies are eco-friendly, efficient and cost-effective. Both phytoremediation and microbe-assisted remediation technologies adopt different mechanisms for HM bioremediation in aquatic ecosystems. Recent advancement of molecular tools has contributed significantly to better understand the mechanisms of metal adsorption, translocation, sequestration, and tolerance in plants and microbes. Albeit immense possibilities to use such bioremediation as a successful environmental clean-up technology, it is yet to be successfully implemented in the field conditions. This review article comprehensively discusses HM accumulation in Indian aquatic environments. Furthermore, it describes the effect of HMs accumulation in the aquatic environment and the role of phytoremediation as well as microbe-assisted remediation in mitigation of the HM toxicity. Finally, the review concludes with a note on the challenges, opportunities and future directions for bioremediation in the aquatic ecosystems.

Keywords Aquatic ecosystem · Heavy metals · Human health · Phytoremediation · Water-treatment plants

Introduction

are distributed in the ecosystem always, their exposure to the humans occurs particularly through numerous anthropogenic

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Evaluation of plant growth promotion properties and induction of antioxidative defense mechanism by tea rhizobacteria of Darjeeling, India

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A total of 120 rhizobacteria were isolated from seven different tea estates of Darjeeling, West Bengal, India. Based on a functional screening of in vitro plant growth-promoting (PGP) activities, thirty potential rhizobacterial isolates were selected for in-planta evaluation of PGP activities in rice and maize crops. All the thirty rhizobacterial isolates were identified using partial 16S rRNA gene sequencing. Out of thirty rhizobacteria, sixteen (53.3%) isolates belong to genus Bacillus, five (16.6%) represent genus Staphylococcus, three (10%) represent genus Ochrobactrum, and one (3.3%) isolate each belongs to genera Pseudomonas, Lysinibacillus, Micrococcus, Leifsonia, Exiguobacterium, and Arthrobacter. Treatment of rice and maize seedlings with these thirty rhizobacterial isolates resulted in growth promotion. Besides, rhizobacterial treatment in rice triggered enzymatic [ascorbate peroxidase (APX), catalase (CAT), chitinase, and phenylalanine ammonia-lyase (PAL)], and non-enzymatic [proline and polyphenolics] antioxidative defense reactions indicating their possible role in