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Perspectives of plant-associated microbes in heavy metal phytoremediation

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ABSTRACT

"Phytoremediation" know-how to do-how is rapidly expanding and is being commercialized by harnessing the phyto-microbial diversity. This technology employs biodiversity to remove/contain pollutants from the air, soil and water. In recent years, there has been a considerable knowledge explosion in understanding plant-microbes-heavy metals interactions. Novel applications of plant-associated microbes have opened up promising areas of research in the field of phytoremediation technology. Various metabolites (e.g., 1-aminocyclopropane-1-carboxylic acid deaminase, indole-3-acetic acid, siderophores, organic acids, etc.) produced by plant-associated microbes (e.g., plant growth promoting bacteria, mycorrhizae) have been proposed to be involved in many biogeochemical processes operating in the rhizosphere. The salient functions include nutrient acquisition, cell elongation, metal detoxification and alleviation of biotic/abiotic stress in plants. Rhizosphere microbes accelerate metal mobility, or immobilization. Plants and associated microbes release inorganic and organic compounds possessing acidifying, chelating and/or reductive power. These functions are implicated to play an essential role in plant metal uptake. Overall the plant-associated beneficial microbes enhance the efficiency of phytoremediation process directly by altering the metal accumulation in plant tissues and indirectly by promoting the shoot and root biomass production. The present work aims to provide a comprehensive review of some of the promising processes mediated by plant-associated microbes and to illustrate how such processes influence heavy metal uptake through various biogeochemical processes including translocation, transformation, chelation, immobilization, solubilization, precipitation, volatilization and complexation of heavy metals ultimately facilitating phytoremediation.

Keywords: Phytoremediation, Heavy metals, Rhizosphere bacteria, Endophytic bacteria, Mycorrhizal fungi, Siderophores, Organic acids, Biosurfactants, 1-aminocyclopropane-1-carboxylic acid