



# Chapter 4

## Green Remediation Harnessing Plant-Based Strategies for Removal of Emerging Soil Contaminants


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### ABSTRACT

*Phytoremediation, a green remediation, presents an eco-friendly approach to combatting environmen-*

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*tal pollution by harnessing the natural detoxification properties of plants. This method utilises various plant species to absorb, accumulate, and transform pollutants, offering a subtle yet effective means of cleansing contaminated soil and water. This highlights the significance of phytoremediation in addressing heavy metal pollution, which poses enduring threats to ecological systems and human health. It explores the diverse applications of phytoremediation, including its effectiveness against heavy metals, radioactive substances, and organic pollutants. The review also discusses the challenges and prospects of phytoremediation, emphasising the importance of identifying suitable plant species and enhancing their resistance to metallic toxins. Overall, phytoremediation emerges as a promising strategy for sustainable environmental remediation, offering long-term benefits for both ecosystems and human well-being.*

## INTRODUCTION

Over recent years, a pronounced upward trend in remediation technologies has emerged due to increasingly high pollution levels (Hou et al., 2020). Many areas worldwide are affected by hazardous pollutants, which present significant threats to ecological systems and all levels of the food web. Heavy metal pollution is especially concerning due to its enduring, non-biodegradable characteristics, highlighting the urgent need for active interventions to lessen its accumulated effects on the environment and living organisms (DalCorso et al., 2008; Farajzadeh Memari-Tabrizi et al., 2021; Marcon et al., 2021). Although heavy metals are naturally present in soil due to natural occurrences such as rock breakdown, erosion, and volcanic actions, human activities have drastically increased their concentrations, even exceeding pre-existing levels. The proliferation of heavy metals in our environment is primarily ascribed to intensive mining, the expansion of industry, and the use of agricultural chemicals, all contributing to widespread pollution and land deterioration (Ghazaryan et al., 2014). Reviews of scientific literature reveal significant contamination of the land, water sources, and the atmosphere with heavy metals, primarily from human-derived sources, signalling an urgent need for remediation (DalCorso et al., 2008; Farajzadeh Memari-Tabrizi et al., 2021; Marcon et al., 2021). Investigations dating back two decades have analyzed the spread, sources, and ecological and toxicological dangers posed by various pollutants in marine bottom layers, the earth's soil, and industrial water (Raj et al., 2014). Wastewater has been identified to hold about 121 different unregulated organic elements, and at least 25 remain even after treatment. In contrast to these degradable organic substances, heavy metals do not break down easily and thus continue to accumulate over time, culminating in enduring food chain contamination.

Soil pollution from harmful metals has significantly reduced soil biological activity. (Raj et al., 2014; Rolka et al., 2020; Wang et al., 2020). Moreover, on-road vehicles are significant sources of air pollution, releasing volatile organic compounds and organic carbon associated with PM<sub>2.5</sub> and PAHs, contributing to substantial harm (Bessagnet et al., 2022). Environmental pollutants pose significant risks to human health and ecosystems, acutely and chronically (Suzuki et al., 2020). Various remediation techniques developed over the past two decades, such as built wetlands, membrane biological reactors, and biosorption, aim to remove harmful pollutants from contaminated environments (L. Liu et al., 2018). However, conventional cleanup methods have faced criticism for their high costs and negative environmental impacts, highlighting the need for sustainable alternatives (Crini et al., 2019). Biological remediation techniques, such as phytoremediation, have been solutions to this problem to the border shift toward more environmentally friendly, environmentally sustainable technologies (Ashraf et al., 2019) (Ghazaryan et al., 2023). However, it is also crucial to recognise that plant-based remediation is generally

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