# Toxicity of Heavy Metals to Legumes and Bioremediation

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# Preface

Rapid industrial operations and constantly dwindling fresh irrigation water sources have resulted in the increased use of industrial or municipal wastewater in agricultural practices, which quite often adds considerable amounts of heavy metals to soil. And therefore, metal concentrations sometimes present in soils commonly go beyond the threshold level, which after uptake by soil microbes including nodule bacteria, rhizobia, and plants such as legumes cause severe toxicity to both microbes and plants. In addition, heavy metals via food chain may cause human health problems also. Maintaining good soil quality is therefore of major practical importance for sustainable agronomic production. Contamination of agronomic soils with heavy metals and their consequent deleterious effects on the production systems have, therefore, received greater attention globally by the environmentalists.

Among crops, legumes, which are grown largely in tropical and semiarid tropical regions, serve as a rich source of protein and provide a significant amount of nitrogen to soils. In addition, legumes are known to improve soil qualities, like organic matter, soil structure and porosity, fertility, microbial structure and composition, etc. In order to promote legume growth in varied ecosystems, microbes forming symbiosis with legumes and collectively called "rhizobia" are applied as inoculant to reduce dependence on chemical fertilizers frequently used in crop including legume production. Besides rhizobia, several other soil-inhabiting microbes possessing plant growth-promoting qualities, generally called as plant growth-promoting rhizobacteria (PGPR), have also been used and practiced as sole bioinoculant or as mixture with host-specific rhizobia for increasing the crop yields. These multipurpose organisms therefore broadly provide a practicable and low-cost substitute to compensate for alarmingly used synthetic chemical fertilizers in high-input agricultural practices in different production systems around the world for enhancing the quantity and seed quality of several crops including legumes. However, reports on the obvious toxicity of heavy metals to legumes and associated microflora and how such toxicities could be reduced/prevented employing inexpensive naturally abundant microbes are poorly documented. To circumvent the metal toxicity problems, several traditional physical and chemical methods have been applied, which, however, have not reached to optimum success level due to various socioeconomic or technical reasons. To overcome such barriers, there is therefore an urgent need to find an inexpensive and easily acceptable technology for metal cleanup from contaminated sites. In this context, both rhizobia and legumes have been found to play important roles in restoring the metal-contaminated soils and subsequently in enhancing legume production in polluted environment. Considering on the one hand the importance of *Rhizobium*–legume interactions in maintaining soil fertility and metal toxicity to symbiotic relationships and the role of PGPR in metal detoxification on the other, grave efforts have been made to compile such demanding research in a single volume.

*Toxicity of heavy metals to legumes and bioremediation* presents numerous aspects of metal toxicity to legumes and suggests quite a few bioremediation strategies that could be useful in restoring contaminated environments vis-a-vis legume production in metal-stressed soils. The mobility and availability of toxic metals, nutritive value of some metals, and the strategies to assess the human health risk by heavy metals are reviewed and highlighted. Heavy metal toxicity to symbiotic nitrogen fixing microorganism and host legumes is dealt separately. A focused insight into the possible effects of heavy metals on seed germination and important physiological functions of plants including popularly grown legumes around the world have been amply reviewed and discussed in this book. The interaction between chromium and plant growth-promoting rhizobacteria and how chromium toxicity could be managed are explored. The influence of glutathione on the tolerance of *Rhizobium leguminosarum* to cadmium is covered in detail. The book further describes in a separate chapter, "Bioremediation: A natural method for the management of polluted environment," several bioremediation strategies commonly used in cleaning up the heavy metal-contaminated sites. "*Rhizobium*–legume symbiosis: A model system for the recovery of metal contaminated agricultural land" has been sufficiently discussed in this book. Microbially mediated transformations of heavy metals in rhizosphere are critically addressed. "Rhizoremediation: A pragmatic approach for remediation of heavy metal contaminated soil" is reviewed and highlighted. Plant growth-promoting rhizobacteria facilitate the growth and development of various plants in both conventional and stressed soils by one or combination of several mechanisms. This interesting aspect of PGPR in the management of cadmium-contaminated soil is dealt separately. The importance of mycorrhizal fungi in enhancing legume production in both conventional and derelict environment and site-specific optimization of arbuscular mycorrhizal fungi-mediated phytoremediation have been reviewed and discussed. Further in this book, heavy metal resistance in plants and putative role of endophytic bacteria are highlighted.

We indeed enjoy sharing especially with legume growers some of the most exciting developments in bioremediation and legume production in stressed environment and presenting this book as a key point of reference for everyone involved in research and development of legumes around the world. The data and methodologies described in this book are likely to underpin the development of sustainable legume production and serve as an important and rationalized source material. In addition, a broad perspective toward an issue of concern to researchers, students, professionals, policymakers, and practitioners in legume production in contaminated soil with minimum resources is highlighted. It would also serve as a valuable resource for agronomists, environmentalists, soil microbiologists, soil scientists, biologists, and biotechnologists involved in the management of contaminated lands.

We are very grateful to our expert colleagues for providing their vital, reliable, and progressive information to construct this book. Chapters in this book are well explained with suitable tables and pictures, and contain most recent literature. We are undeniably very thankful to our family members for their constant and unrelenting support during the whole period of book preparation. And most of all, we are extremely thankful to our lovely children Zainab and Butool for helping us to avoid some tense moment during book preparation by their joyful activities. We are also very pleased with the book publishing team at Springer-Verlag, Austria, who always provided us their unconditional support in replying to all our queries very quickly. Finally, there may be a few basic errors/inaccuracies or printing mistakes in this book, for which we feel sorry in anticipation. However, if such mistakes are brought to our notice at any stage, we will certainly try to correct and improve them in subsequent print/edition. Any suggestion or decisive analysis of the contents presented in this book by the readers is welcome.

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