Chapter 7
Phytoremediation:
A Modern Approach

Suparna Pal
https://orcid.org/0000-0002-6975-4156
Lady Brabourne College, Kolkata, India

ABSTRACT

This chapter includes the sources of cadmium and chromium contamination of soil and various detrimental effects on plants and animals. Ecofriendly approach of soil clean up by phytoremediation is the main focus of the author. Heavy metal-induced oxidative stress of plants and their detoxification potentiality has been discussed here to create a wholesome idea about the basic and acute need of phytoremediation. Both enzymatic and non-enzymatic antioxidative defense mechanisms and various other biochemical parameters of metal hyperaccumulator plants are mentioned.

INTRODUCTION

Heavy metal contamination of soil is a global problem due to its negative impact on every component of the ecosystem, threatening the health of vegetation, wildlife and human beings. Bioavailability and bioaccumulation of different heavy metals in aquatic and terrestrial ecosystem are of tremendous global significance as they mainly accumulate in the soil, ground and bottom sediments of seas and oceans and have a long term effect on the biotic factor of this world. There is an absolute need of affordable, environment friendly and sustainable technological solution. Now a day's chemical decontamination of agricultural lands are getting replaced by ecofriendly bioremediation process. Phytoremediation is the foremost attribute of bioremediation. Phytoremediation is an eco-friendly and cost-effective technology for the remediation of heavy metal contaminated soil and water through implication of plants ability to accumulate heavy metals in their harvestable shoot parts. The prerequisite of phytoremediation is identification of native heavy metal tolerant plants with metal tolerance and detoxification capacity and considerable amount of metal uptake as well as accumulation potentiality. By bioremediation any metal contaminated land of India can be converted into agricultural land.

DOI: 10.4018/978-1-7998-4888-2.ch007

Heavy metals interfere and affect biochemical and physiological processes such as photosynthesis, respiration, cell elongation, plant water relationship, nitrogen metabolism and mineral nutrition. Heavy metal induced soil pollution is anthropogenic in origin, such as by the residues of metalliferous mining technology, heavy automobile traffic, smelters, household and industrial wastes (Clement et al. 2007). Depending on the type of industries in the vicinity agricultural lands get contaminated with different metals of no biological roles such as As, Cd, Cr, Pb, Ni etc are deposited in the soil. Among these metals, Cd and Cr are the two most important toxic pollutants affecting both animal and plant physiology extremely. Having maximum industrial usage, Cd and Cr pollution of soil and water is an alarming problem in urban and semi urban areas of India and is of international concern also (Bah et al. 2011). Heavy metal exposure occurs significantly by occupational exposure. As these two metals are higly used in industries (tanning, electroplating, mineral fertilizers, Ni- Cd battery production, paints used for glass and ceramics, soft drink plants) almost 65% of industrial workers and local people living in the close vicinity of these industrial areas are regularly exposed to the hazards of these two toxic metals (Sethi et al. 2006). India, being a third world country, here acute emphasis has been given to the development of industrial hub for the employment of huge population. But the protection and restoration of the environment has not been given same importance or weight age and is almost overlooked.

BACKGROUND

Cadmium

Divalent heavy metal cation Cd with long biological half life is one of the most hazardous elements and a major contaminants due to its greater water solubility and higher phytotoxicity (Clemens 2006). Cd is ubiquotus and biologically non essential. According to the Agency for Toxic Substances and Disease Registry (2007), the position of Cd is 7th in the list of "Top twenty hazardous substances, 2007". Unlike Cu and Fe; Cd is a non redox metal, unable to participate in Fenton reactions but it leads to the formation of reactive oxygen species indirectly by interfering antioxidative defense system of plants (Cargnelutti et al. 2006). Being highly mobile Cd is can be readily taken up by plant roots and transferred to shoot. It can enter the food chain and become detrimental to human and animal health (Chen et al. 2007). Various soil parameters such as pH, redox potential, and rhizosphere chemistry determine the Cadmium bioavailability. Soluble Cd could enter roots and prefers apoplastic or symplastic pathway (Redjala et al. 2009). Being non biodegradable Cd tends to accumulate in atmosphere causing ecological risks. Daily consumption of Cd contaminated foods is a great threat to human health. In Japan, Cd contaminated rice caused Itai Itai disease near Jinzu River basin in the middle of the 20 th century. The risk to health from certain elements in food can be assessed by comparing estimates of dietary exposures with the Provisional Tolerable Weekly Intakes (PTWI) and Provisional Maximal Tolerable Daily Intakes (PMTDI) recommended by the Joint Expert Committee on Food Additives (JECFA) of the Food and Agriculture Organisation (FAO) of the United Kingdom and the World Health Organisation (WHO). For Cd the PTWI set up by JECFA was 7 μg/kg body weights. Recently according to JECFA (2011) the previous PTWI of 7 μg/kg of body weight has been withdrawn, and a PTMI (Provisional Tolerable Monthly Intakes) of 25 μg/kg of body weight has been established because of cadmium's exceptionally long half-life .