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Hand Book of Agriculture & Plant Sciences

June 2021

Publisher: ABS BOOK, PUBLISHERS AND EXPORTERS, NEW DELHI · ISBN: 978-93-91002-25-1

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GOVERNMENT GENERAL DEGREE COLLEGE, ...

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References (1,021) Figures (1)

Abstract and Figures

Plants are a fascinating group of plants that have been dominating the earth for 400 million years. During evolution, they have undergone series of evolutionary changes to suit themselves with the surrounding environment. These evolutionary changes not only included morphological changes to suit varied climatic conditions but also armed with intricate physiological changes to synchronize with the former and fortify better adaptability. These physiological changes later proved to be

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Heavy Metal Bioremediation of Agricultural Soils for Sustainability and Food Safety

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Introduction

Increased industrial and anthropogenic activities such as thermal power plant, mining, smelting, varnish and mining sector as well as agricultural wastes such as inorganic pesticide and domestic wastes such as E waste batteries are known to release toxic heavy metals such as Cr, Ni, Cu, Pb, Cd and Zn in soils and water. This release of metal beyond the permissible limit may be detrimental to both the flora and fauna. These metals possess

threats as they are non-biodegradable and tend to bio accumulate. It also progresses in the food chain leading to several side effects such as inhibition of plant growth by altering the biochemical, physiological and metabolic processes and also results in alteration of soil microflora (Nagajyoti et al., 2010). However, the impact of the metals is largely influenced by the solubility and type of complexation it forms with different ligands this is determined largely by pH of the soils (Norvell, 1984). Metals can also be associated with different exchangeable and non-exchangeable ions and insoluble organic metals compounds such as oxides, hydroxides, phosphates, carbonates and silicates.

The process of mitigation of heavy metals from contaminated soils is always a challenging task and can be done in four different methods which includes *exsitu* treatment and containment as well as *insitu* treatment and containment techniques (Wang et al., 2004). The different techniques which plays a pivotal function in remediation can be both chemical mediated, biologically mediated which include processes like capping, dredging, natural attenuation, soil washing, precipitation, physical exclusion, volatilization, vitrification, thermal desorption, coagulation-filtration, solid-liquid separation, electrokinetic treatment, oxidation-reduction, and membrane technologies (Khulbe and Matsuura, 2018; Wang et al., 2012). However, use of chemical agents in treatment processes is not an effective solution as it also generate secondary waste products and also require energy and is not at all a cost-effective process. In order to overcome such draw backs eco-friendly techniques such as bacterial bioremediation, phytoremediation and bacteria mediated phytoremediation are used to mitigate contaminated land (Ali et al., 2013; Kotrba et al., 2009). *Exsitu* bioremediation treatments can be classified into various types including bio-piling (Whelan et al., 2015), windrow (Coulon et al., 2010), bioreactor and land farming, in all the cases the pollutant were excavated from polluted sites. For *ex situ* bioremediation several factors are considered which are the total cost, depth of pollution, type of pollutant as well as degree of pollution. However, *insitu* bioremediation does not require any excavation of the polluted soils from the site of origin and can naturally occur in the site or are of several types such as bioventing, biosparging, bioslurping and phyto remediation. However, none of these techniques alone can act as a silver bullet to remove the pollutant from the site.

In this chapter we discuss in details the origin of different heavy metal from different sources as well as the different possible

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