Chapter 11
Newer Approaches in Phytoremediation:
An Overview

ABSTRACT

The heavy metal pollution problem is all over the world. Plant-growth-promoting bacteria (PGPB) has transformed heavy metals present in the soil, which removes and minimizes their toxic effects. This chapter highlights the role of plant-growth-promoting bacteria, chelating agents, and nanoparticles for remediation of heavy metals; their mechanism of action; and their applications approach of hyperaccumulation. Therefore, this chapter focuses on the mechanisms by which microorganisms, chelating agents, and nanoparticles can mobilize or immobilize metals in soils and the nano-phytoremediation strategies are addressed for the improvement of phytoextraction as an innovative process for enhancement of heavy metals removal from soil.

INTRODUCTION

Heavy metals is a serious environmental problem which affecting human health and plant (Aldoobie and Beltagi, 2013; Park et al., 2014). The use of large amount of fertilizers has been produced heavy metals into non-pollluted sites which affect dramtically to agriculture (Saba et al., 2015). One of the most toxic heavy metal involved in many fertilizers is lead (Pb), which can be

DOI: 10.4018/978-1-5225-9016-3.ch011

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absorbed and translocate into plants and easily enter into food chain. Heavy metal contaminants movement from soil to the ground water is very slow because of less mobility so it is not easily absorbed by the plant (Rodriguez et al., 2011; Lori et al., 2015). Therefore heavy metals are low in the upper parts such as leaves, seeds and fruits because of high amount of accumulation in roots (Mishra and dubey, 2005; Ullah et al., 2015). High concentration in soil can also affect to microbial activity with soil fertility (Gao et al., 2010; Yuan et al., 2015). Heavy metals such as Zn, Cu and Mn, Al, Mg are necessary as micronutrients, but high amount of these heavy metals can be caused toxicity and negative effect on human health (Langer et al., 2009; Ali et al., 2013). Some other heavy metals such as Cd, As, Pb, Hg and Ni, are non-nutritional and toxic elements present in soil (Jourand et al., 2010).

Plants under heavy metal stress condition it produces a high level of reactive oxygen species (ROS) such as hydrogen peroxide (H_2O_2), hydroxyl radicals (OH), superoxide radicals (O_2) catalse, which result in damages to plant cell or tissue (Wang et al., 2015; Migocka et al., 2014). Reactive oxygen species produced continuously in different compartments with antioxidant molecule under as by-product (Reddy et al., 2005; Kwankua et al., 2012; Girisha and Ragavendra, 2009; Palma et al., 2013; Dubey et al., 2014). However the critical imbalance and excess amount of production ROS, antioxidant molecule in plant which is depleted and creates disorders in plant enzymatic activity, all type of biochemical molecules including cell wall, membrane lipids, protein, amino acid chain and carbohydrates figure 1 (Kaur et al., 2015; Qiao et al., 2015; Gratao et al., 2005). They also damage cell membrane, loss of cell metabolites, reduction in cell growth and impaired metabolic functions (Goncalves et al., 2007a,b; Lee et al., 2007; Merlot et al., 2014; Morel et al., 2009).

The conventional remediation technologies are cost effective more expensive and some of the techniques did not remove heavy metal effectively. Therefore, it is important to develop economically practical and more effective method to decontaminate soils from heavy metal contamination. The most popular advantage of phytoremediation is low cost effectiveness (Abdul and Schroder, 2009). It can be up to 1000-fold cheaper compared to conventional method such as (flotation-filtration, evaporation, ion-exchange, electrodialysis and ultrafiltration). It has been estimated to clean up one acre of sandy loam soil to a depth of 55 cm will cost 60,000-100,000$ compare to 400,000$ for conventional using traditional soil removal methods (Ali et al., 2013).

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