# Chapter 6
# Role of Plant Growth Promoting Bacteria (PGPB) for Bioremediation of Heavy Metals: An Overview

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## 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 PGPB for remediation of heavy metals, their mechanism of action, and their applications approach of hyperaccumulation. Further, it also highlights the role of uptake and detoxification of metals by cellular mechanisms which facilitate the bioremediation of heavy metals from contaminated areas. Bacteria may also enhance nutrient uptake, increasing plant growth and defenses while diminish heavy metals intake and their toxic effects. Therefore, this chapter focuses on the mechanisms by which microorganisms can mobilize or immobilize metals in soils and the bioremediation strategies are addressed for the improvement of phytoextraction as an innovative process for enhancement of heavy metals removal from soil.*

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## INTRODUCTION

The heavy metal pollution problem is all over the world. The chemicals released into the soil in the form of cadmium (Cd), cobalt (Co), copper (Cu), lead (Pb), zinc (Zn), mercury (Hg), chromium (Cr), antimony (Sb) and nickel (Ni) elements. Some of these elements are essential for many physiological functions in living beings while others have no such function in biological function in required level (Fassler et al., 2010; Dubey et al., 2014). These elements are commonly found in fungicides, animal waste, fertilizers and sewage sludge in soil. Deposition of these industrial wastes can increase the concentration of the elements at toxic level (Fassler et al., 2010). The use of a lot of fertilizers has been released heavy metals which dramatically affects to the agriculture (Saba et al., 2015). Lead (Pb) is the most toxic heavy metal found in several fertilizers, which is further translocated into plants and easily enter into the food chain. Heavy metal contaminants movement from soil to the water (ground level) is very slow because of the less mobility of them and it is the major cause of their absorption by plants (Rodriguez et al., 2011; Lori et al., 2015).

Plants under heavy metal stress produce reactive oxygen species (ROS). ROS includes hydrogen peroxide ($H_2O_2$), superoxide radicals ($O_2$), hydroxyl radicals (OH) and catalase which result in damages to plant cell or tissue (Migocka et al., 2014; Wang et al., 2015,). ROS produced continuously in different compartments of the plant with a number of antioxidant molecule as by-products (Kwankua et al., 2012; Palma et al., 2013; Dubey et al., 2014). However, the critical imbalance and an overload amount of production of ROS and antioxidant molecule in plant creates disorder and effect the plant enzymatic activity (Gratao et al., 2005; Qiao et al., 2015). There are number of remediation technologies are used such as landfill, excavation, thermal treatment, recovery by means of electricity and leaching of acids but those are not suitable due to their high cost and very less successful for specific metal contamination site. Therefore, it is important to develop economically practical and more effective method to decontaminate soils from heavy metal contamination.

The advantage of phytoremediation, it is a low-cost technology (Abdul and Schroder, 2009). It is about 1000-fold cheaper in compare to other conventional methods such as (flotation-filtration, evaporation, ion exchange, electrodialysis, and ultrafiltration). For example, to clean about 1 acre of sandy soil (55 cm depth) will cost around 60,000-100,000 $ as compare to 400,000 $ for conventional methods (Ali et al., 2013). Phytoremediation technique involves several techniques such as Phyto filtration, rhizofiltration, phytoextraction, phytostabilization, Phyto immobilization and phytodegradation, and rhizodegradation (Figure 1) (Abdul and Schroder, 2009; Ali et al., 2013). Phytoextraction is the most efficient and useful technique among them but it is much more difficult than others. Hyperaccumulator plants are those which uptake and tolerate about hundred times greater contaminants