Chapter 11

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ABSTRACT

In this chapter authors have discussed the role of plants to develop contaminant free environment. This concept is also known as Phytoremediation. Phytoremediation is a word formed from the Greek prefix “phyto” meaning plant, and the Latin suffix “remedium” meaning to clean or restore. This technology has been receiving attention lately as an innovative, cost-effective alternative to the more established treatment methods used at hazardous waste sites. Phytoremediation can be classified into different applications, such as phytofiltration or rhizofiltration, phytostabilization, phytovolatilization, phytodegradation and phyto-extraction etc. The chapter will deal with phytoremediation, its advantages, limitations and in detail techniques of classification and application.

1. INTRODUCTION

Soil is the fundamental foundation of our agricultural resources, food security, global economy and environmental quality. Increasing demand for agricultural products has led to extensive cultivation in agricultural lands (Oh et al., 2013). Applying fertilizers, pesticides and herbicides is necessary to protect the quality and quantities of these products. However, the excessive use of these agro-chemicals creates environmental problems, such as accumulation of these chemical substances in the soil and plant uptake (Sahibin et al., 2002). With the development of urbanization and industrialization, soils have become increasingly polluted by heavy metals and organic pollutants, which threaten ecosystems, surface and ground waters, food safety and human health (Li et al., 2009). The main factors contributing to soil pollution are the increased growth of industry; nearly 1000 new chemicals are being synthesized every year (Shukla et al., 2010). According to Third World Network reports, more than one billion pounds

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(450 million kilograms) of toxins are released globally in air and water. Therefore environmental pollution with organic xenobiotics (pesticides, pharmaceuticals, petroleum compounds, polychlorobiphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) etc.) is a global problem (Woolhouse, 1983). Excessive metal concentration in soils pose significant hazard to human, animal and plant health, and to the environment in general. Contamination of soils with toxic metals has often resulted from human activities, especially those related to mining, industrial emissions, disposal or leakage of industrial wastes, application of sewage sludge to agricultural soils, manure, fertilizer and pesticide use. Due to the potential toxicity and high persistence of metals, soils polluted with these elements are environmental problem that requires an effective and affordable solution. Although a number of techniques have been developed to remove metals from contaminated soils, many sites remain contaminated because of economic and environmental costs to clean up those sites with the available technologies are too high. According to Ensley (2000), the estimated expenses incurred in the remediation of a site contaminated with Pb using the conventional excavation-landfill approach most commonly practiced in the United States are approximately $150-$350 t⁻¹. Taking into account such a high demand of economic resources, methods of environmental restoration of metal-polluted soils using a plant-based technology have attracted increasing interest in the last two decades. In this context, phytoremediation has been developed as a cost effective and environmentally friendly remediation method of contaminated soils.

The idea of using metal-accumulating plants to remove heavy metals and other compounds was first introduced in 1983, but the concept has actually been implemented for the past 300 years on wastewater discharges. The generic term phytoremediation consists of the Greek prefix phyto (plant) attached to the Latin root remedium (to correct or remove an evil) (Cunningham et al., 1996). Phytoremediation technology is an innovative field of science and technology for cleaning up contaminated soil, water and air (Pulford and Watson, 2003). Certain plants have endogenous, genetic biochemical and physiological qualities to combat against the soil, water and air pollution (Meagher, 2000). Phytoremediation, also called green remediation, botano-remediation, agroremediation, or vegetative remediation is considered a publicly appealing (green) remediation technology that uses vegetation and associated microbiota, soil amendments and agronomic techniques to remove, contain, or render the heavy metals harmless in the soil (Cunningham et al., 1996). Phytoremediation for metal-contaminated soils represents a market opportunity of approximately US$1 billion per year in the USA alone; the U.S. phytoremediation market currently comprises only 0.5% of the total remediation market, equivalent to circa US$ 100-150 million per year (Glass, 2000) (see Table 1).

2. SIGNIFICANCE OF PHYTOREMEDIATION (VISHNOI ET AL., 2008)

1. Plants control 80% of the energy in most ecosystems and do not need external energy sources.
   a. Photosystem I make NADPH.
   b. Reduce CO₂ and make large biomass.
   c. Can reduce toxic metal ions.
2. Plants grow extensive root systems (100 million/acre/yr).
   a. Plants mines 16 metals for normal growth.
   b. Some plants hyper accumulate heavy metals.
   c. Some plants degrade toxic organic chemicals.
3. Phytoremediation is a sound support to bacterial remediation methods.