Phytoremediation and hyperaccumulator plants

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Abstract

Phytoremediation is a group of technologies that use plants to reduce, remove, degrade, or immobilize environmental toxins, primarily those of anthropogenic origin, with the aim of restoring area sites to a condition useable for private or public applications. Phytoremediation efforts have largely focused on the use of plants to accelerate degradation of organic contaminants, usually in concert with root rhizosphere microorganisms, or remove hazardous heavy metals from soils or water. Phytoremediation of contaminated sites is a relatively inexpensive and aesthetically pleasing to the public compared to alternate remediation strategies involving excavation/removal or chemical *in situ* stabilization/conversion. Many phytoremediation plans have multi-year timetables, but since most sites in need of remediatrion have been contaminated for more than ten years, as such a ten year remediation plan does not seem excessive. Seven aspects of phytoremediation are described in this chapter: phytoextraction, phytodegradation, rhizosphere degradation, rhizofiltration, phytostabilization, phytovolatization, and phytorestoration. Combining technologies offer the greatest potential to efficiently phytoremediate contaminated sites. The major focus of this chapter is phytoextraction of arsenic, cadmium, chromium, copper, mercury, nickel, lead, selenium, and zinc.

1 Introduction to phytoremediation

Phytoremediation is a term applied to a group of technologies that use plants to reduce, remove, degrade, or immobilize environmental toxins, primarily those of anthropogenic origin, with the aim of restoring area sites to a condition useable for private or public applications. To date, phytoremediation efforts have focused on the use of plants to accelerate degradation of organic contaminants, usually in concert with root rhizosphere microorganisms, or remove hazardous heavy metals from soils or water. Phytoremediation of contaminated sites is appealing because it is relatively inexpensive and aesthetically pleasing to the public compared to alternate remediation strategies involving excavation/removal or chemical *in situ* stabilization/conversion. Seven aspects of phytoremediation are described in this chapter: phytoextraction, phytodegradation, rhizosphere degradation, rhizofiltration, phytostabilization, phytovolatization, and phytorestoration. However, the major focus is on phytoextraction.

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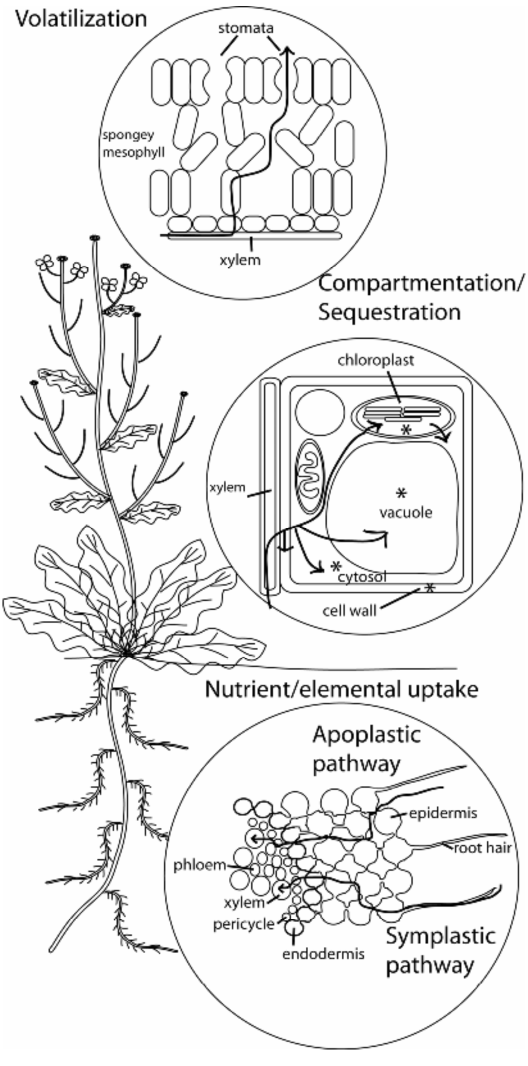

Fig. 1. Pathway of metal/nutrient uptake in plants. Soluble metals can enter into the root symplast by crossing the plasma membrane of the root endodermal cells or they can enter the root apoplast through the space between cells. If the metal is translocated to aerial tissues, then it must enter the xylem. To enter the xylem, solutes must cross the Casparian strip, a waxy coating which is impermeable to solutes, unless they pass through the cells of the endodermis probably through the action of a membrane pump or channel. Once loaded into the xylem, the flow of the xylem sap will transport the metal to the leaves, where it must be loaded into the cells of the leaf, again crossing a membrane. Once in the shoot or leaf tissues, metals can be stored in various cell types, depending on the species and the form of the metal, since it can be converted into less toxic forms (to the plant) through chemical conversion or complexation. The metal can be sequestered in several subcellular compartments (cell wall, cytosol, vacuole) or volatilized through the stomata.