Phytoremediation Technology in Remediation of Contaminated Soils

Phytoremediation: eco-friendly approach that utilizes the natural properties of plants to remediate contaminated soils. By growing plants in the contaminated sites, contaminants in soils will be removed, immobilized, or degraded, and the cost is much less expensive than other traditional methods.

Approximately 400 plant species have been classified as hyperaccumulators of heavy metals, such as grasses, sunflower, corn, hemp, flax, alfalfa, tobacco, willow, Indian mustard, poplar, water hyacinth, etc.

Phytoremediation of contaminated soils is generally believed to occur through the following mechanisms:

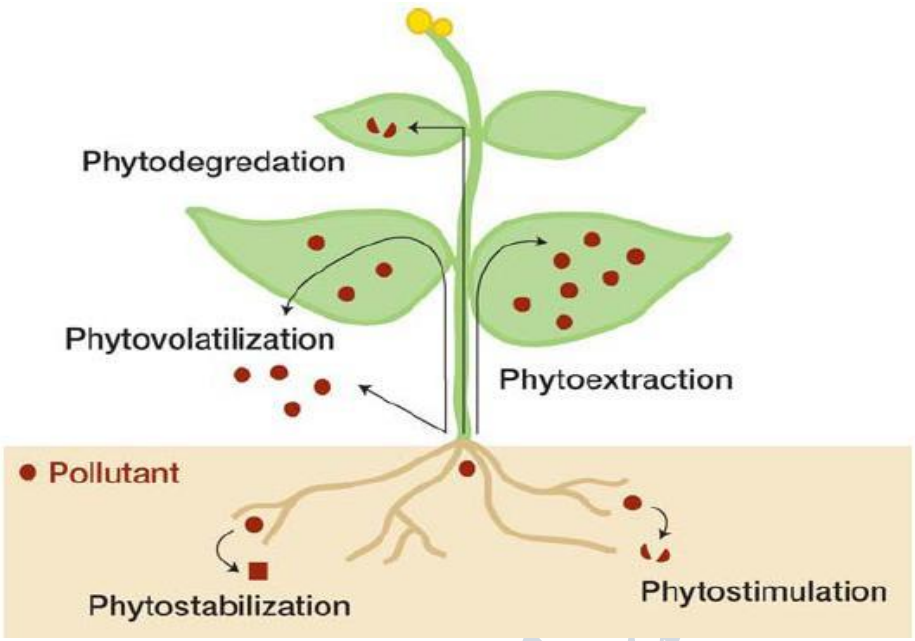
1) phytoextraction: Plants absorb contaminants and store in above-ground shoots and the harvestable parts of roots.

2) phytostabilization: Roots and their exudates immobilize contaminants through adsorption, accumulation, precipitation within the root zone, and thus prevent the spreading of contaminants.

3) phytodegradation: Plant enzymatic breakdown of organic contaminants, both internally and through secreted enzymes.

4) phytovolatilization: Contaminants taken up by the roots through the plants to the leaves and are volatized through stomata where gas exchange occurs.

5) rhizodegradation or phytostimulation: Plant roots stimulate soil microbial communities in plant root zones to break down contaminants.



Mechanisms of Phytoremediation

Phytoremediation is applicable to a broad range of contaminants, including

1) heavy metals

2) radionuclides

3) organic compounds like chlorinated solvents, polycyclic aromatic hydrocarbons, pesticides/insecticides, explosives, and surfactants.

Phytoremediation processes depend on the ability of plants to take up and metabolize pollutants to less toxic substances. The uptake, accumulation and degradation of contaminants vary from plant to plant.

The plants used in phytoremediation are generally selected on the basis of

1) Their growth rate and biomass

2) Their ability to tolerate and accumulate contaminants

3) The depth of their root zone, and their potential to transpire groundwater

4) Plant should grow quickly in a wild range of different conditions.

The most positive characteristics of phytoremediation

1) A natural and *in situ* (does not need to remove the soil out of the Place) remediation system driven by solar and green plants.

2) It is faster than natural attenuation and can conserve the soil resources

3) It is inexpensive, and does not induce the secondary contamination

4) Reduce movement of pollutants towards groundwater

5)Sustains the soil structure, and enhance the soil quality and productivity

6) Soils followed phytoremediation are still or more suitable for its original application particularly for agricultural application, thus preventing the loss of soil resources

7) The costs are very low in comparison to current other physical or chemical methods

Phytoremediation process of inorganic contaminants, and the means for enhanced phytoremediation.

Phytoremediation of various inorganic pollutants such as Cd, Cr, Pb, Cu, Zn, Co, Ni, Se, Cs and As. This is mainly based on the use of natural hyperaccumulator plants that characterized with exceptional metal-accumulating capacity, the ability to

accumulate metals in their shoots and an exceptionally high tolerance to heavy metals.

At present, there are totally more than 400 species of hyperaccumulator plants for As, Cd, Mn, Ni, Zn etc. have been found. For example of some hyperaccumulator plants and their accumulation concentration (mg/kg dw:dry weight) for various metals are: Thlaspi caerulescens, 51600 for Zn and 18000 for Cd; Ipomea alpine, 12300 for Cu; and Pteris vitatta, 20,000 for As

Enhanced phytoremediation generally includes the following several ways:

1) Enhanced heavy metal phytoextraction with chemicals: This method is to increases mobility of metals in soil by application of chelating agents or surfactants, such as citric acid, EDTA, and NTA, so that the metals can be taken up more easily by plants

2) Utilization of Genetically engineered plants: through genetically altering the high biomass plants to extract larger amounts of metal from soils, or improving the biomass production of some hyperaccumulator plants.

3) Agricultural work techniques: this method is to enhance phytoremediation efficiency by promoting plant growth and microbial activities with suitable fertilization, carbon source addition, or cultivation systems.

4) Using plant-microbe combination systems: The rhizosphere is inoculated with new microorganism which is more effective in degrading the contaminant than the local microflora. Good plant-microbe combination can promote the activity of the effective microbes and the plant growth. It is also reported that inoculation of mycorrhizae to some plants may promote the uptake, translocation and accumulation of soil metals