

Phytoremediation an Alternative

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Abstract

Phytoremediation is a process that uses plants to remove, transfer, stabilize, and destroy contaminants in soil and sediments. Contaminants may be either organic or inorganic. This process includes six main mechanisms namely Phytostabilisation, Phytoextraction, Rizofiltration, Phytodegradation, Rizodegradation and Phytovolatilisation which progress as per the nature of the contaminant to be dealt with. Unlike organic compounds, metals cannot be degraded, and clean up usually requires their removal. The major hazardous metals of concern in India in terms of their environmental load and health effects are lead, mercury, chromium, cadmium, copper and aluminium. Their source is mostly anthropogenic- industrial activity, vehicles, etc. Most of the conventional remedial technologies are expensive and inhibit the soil fertility; this subsequently causes negative impacts on the ecosystem. Hence, in order to deal with these contaminants in an eco-friendly manner considerable numbers of plants have been identified worldwide which are hyper accumulators of various heavy metals. Phytoremediation is gaining worldwide importance due to its low cost involvement and eco-friendliness. This paper deals with different Phytoremediation plants, its mechanism and relative advantages over others heavy metal removal technologies.

Keywords: Phytoremediation, Hyper accumulators, Low cost, Eco-friendliness.

1. Introduction

The idea of using plants as a removal of toxicity in soil is very old and cannot be traced, however the development of science saturated with series of researches has

made this idea into reality which is known as Phytoremediation. Phytoremediation is defined as the use of green metal accumulating plants for removal of heavy metals from soil as well as water. In a simple sense it can be regarded as a solar driven pump for the extraction of heavy metals from the environment.

Heavy metal pollutants, because of their non destroy ability and non biodegradability; continue to be a global concern. Heavy metal ions are highly carcinogenic, teratogenic and mutagenic even at traces concentration. Almost all heavy metals are toxic at higher concentration and a few are severe poisonous for all form of life, including microorganisms, higher plants, animals and man. Of greater concern is the exposure of these heavy metals for a longer duration of life resulting in carcinogenic effects. The volume of toxic waste produced as a result is generally a fraction of that of many current, more invasive remediation technologies, and the associated costs are much less. This review paper deals with the heavy metals sources, their effects and the plants as well as their mechanism which can avant-garde in the removal of these heavy metals.

2. Heavy Metals

2.1 Sources

Source of heavy metal can be identified as natural and anthropogenic sources. Naturally heavy metals are released into the sediments and air through chemical as well as physical weathering of igneous, metamorphic rocks and soil. They are also generally associated with volcanic activities, wind erosion, forest smoke fire and fossil fuels. The level of metals released by such natural activities are harmless to man and environment. Whereas on the contrary anthropogenic sources such as mines, foundries, smelters, electroplating, coal burning power plants etc. imposes a harmful threat to man as well as environment.

The table below gives the list of heavy metals in the environment their sources with their toxic response.

Table 1: Heavy Metals, their sources and toxic response.

Heavy metals ions	Sources	Toxic response
Cr	Timber treatment, leather tanning, pesticides and dyes	Ulceration, vomiting, diarrhea, fever muscle cramps, alteration of genetic materials, coma and even death
Cd	Electroplating, batteries and fertilizers	Damage to central nervous system and immune system, DNA damage, reduce growth, bone defects, lung cancer and death from pulmonary odema may occur

Cu	Timber treatment, fertilizers, fungicides, electrical and pigments	Irritation in eyes, nose and mouth, headaches, dizziness, nausea, diarrhea and brain damage
Hg	Mining, transportation, processing of mercury ores, plastic, batteries and fertilizers	Brain damage, birth defects and miscarriages, sensory impairment, hearing loss, head aches
Pb	Batteries, metal products	Biochemical effects in synthesis of hemoglobin, effects on kidneys, rise in blood pressure
As	Timber treatment, paints and pesticides	Vomiting throat and stomach pain, DNA damage, infertility and miscarriage with women

3. Categories of Phytoremediation

3.1 Phytostabilisation

In Phytostabilisation, transcription and root growth are used to immobilize metal contaminants by reducing leaching, controlling erosion, creating an aerobic environment in the root zone, and adding organic matter to the substrate that binds metals. Thus contaminants are absorbed and accumulated by roots, adsorbed onto the roots, or precipitated in the rhizosphere. It not only prevents migration of contaminants into the groundwater or air, but also reduces the bioavailability of the contaminant.

3.2 Phytoextraction

Plant roots uptake metal contaminants from the soil and translocates them to their above soil tissues. This category of Phytoremediation is important at sites polluted with more than one type of metal contaminants. Plants grown on the highly contaminates sites should be a hyper accumulator. Phytoextraction involves repeated cropping of plant until the metal concentration in the soil has reached the acceptable (targeted) level.

3.3 Rhizofiltration

In Rhizofiltration, the roots of plants are used to adsorb or absorb the metal, which are subsequently removed by harvesting the whole plant. This process is concerned with the remediation of contaminated groundwater. Contaminants are either adsorbed onto the root surface or are absorbed by the plant roots.

3.4 Phytovolatilisation

Phytovolatilization is the uptake and transpiration of a contaminant by a plant, with release of the contaminant or a modified form of the contaminant to the atmosphere from the plant through contaminant uptake, plants metabolism, and plant transpiration. Phytovolatilization has mainly been applied to groundwater, but it can be applied to

soil, sediments, and sludges. Contaminants could be transformed to less-toxic forms, such as elemental mercury and dimethyl selenite gas.

3.5 Phytodegradation

This process includes breakdown of organic contaminants by internal and external metabolic processes driven by the plants. Metabolic processes hydrolyse organic compounds into smaller units that can be absorbed by the plants. Phytodegradation is used in the treatment of soil, sediments, sludges, and groundwater. Surface water can also be remediated using Phytodegradation.

3.6 Rhizodegradation

Rhizodegradation is the breakdown of an organic contaminant in soil through microbial activity that is enhanced by the presence of the root zone. Rhizodegradation is also known as plant-assisted degradation, plant-assisted bioremediation, plant-aided in situ biodegradation, and enhanced rhizosphere biodegradation.

4. Application of Phytoremediation

The applications of different mechanisms discussed above are given in the below table:

Table 2: Overview of different mechanisms of Phytoremediation.

Mechanism	Media	Contaminants	Plants
Phytostabilisation	Soil, sediment, sludges	As, Cd, Cr, Cu, Hs, Pb, Zn	Indian mustard, hybrid poplars, grasses
Phytoextraction	Soil, sediment, sludges	Metals: Ag, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Zn; Radionuclide: 90Sr, 137Cs, 239Pu, 238,234U	Indian mustard, pennycress, alyssum sunflowers, hybrid poplars
Rhizofiltration	groundwater, surface water	Metals, radio nuclides	Sunflowers, Indian mustard, water hyacinth
Phytovolatilisation	Soil, sediment, sludges, groundwater	Chlorinated solvents, some inorganic (Se, Hg, and As)	Poplars, alfalfa, black locust, Indian mustard
Phytodegradation	Soil, sediment, sludges, groundwater, surface water	Organic compounds, chlorinated solvents, phenols, herbicides	Algae, stonewort, black willow, bald cypress, hybrid poplar

Rhizodegradation	Soil, sediment, sludges, groundwater	Organic compounds (TPH, PAHs, pesticides chlorinated solvents PCBs)	Red mulberry, grasses, hybrid poplar, cattail, rice
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5. Advantages of Phytoremediation

- Amendable to a variety of organic and inorganic compounds.
- Easy to implement and maintain.
- The plant biomass containing the extracted contaminant can be a resource. For example, biomass that contains selenium (Se), an essential nutrient, has been transported to areas that are deficient in Se and used for animal feed. This can be achieved by Phytoextraction.
- It has a lower cost and is less disruptive than other more-vigorous soil remedial technologies. Revegetation enhances ecosystem restoration.
- Mineralization of the contaminant can occur with the help of Rhizodegradation. In the process of Phytodegradation Contaminant degradation due to enzymes produced by a plant can occur in an environment free of microorganisms(for example, an environment in which the microorganisms have been killed by high contaminant levels). Plants are able to grow in sterile soil and also in soil that has concentration levels that are toxic to microorganisms.

6. Conclusion

We conclude that Phytoremediation is a low cost and eco-friendly remedy for the treatment of heavy metals in the environment

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