



A review approach to check applicability of phytoremediation

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Abstract

Phytoremediation is the green strategy for the future. Plants and their parts rhizospheric microorganism which absorbs the pollutant from the soil and water. Contaminants such as metals, pesticides, solvents, explosives, and crude oil and its derivatives, have been mitigated in phytoremediation projects worldwide. Many plants such as mustard plants, alpine pennycress, hemp, and pigweed have proven to be successful at hyperaccumulating contaminants at toxic waste site. There are many other processes for remediation but Phyto remediation process is useful because it is low-cost mechanism. Many heavy metals are also extract from the soil as well as water. This review concentrates on the most developed subsets of phytoremediation technology and on the biological mechanisms that make phytoremediation work.

Keywords: phytoremediation, plants, rhizospheric, soil

Introduction

Phytoremediation is usually applied to contaminated soil or water environments that are static. Some of the examples include the restoration of abandoned metal mine workings and sites where polychlorinated biphenyls have been dumped during the manufacture and mitigation of ongoing coal mine, discharges reducing the impact of contaminants in soils, water, or air. Phytoremediation is proposed as a cost-effective plant-based approach of environmental remediation that takes advantage of the ability of plants to concentrate elements and compounds from the environment and to detoxify various compounds. The concentrating effect results from the ability of certain plants called hyperaccumulators to bioaccumulate chemicals. The remediation effect is quite different. According to Kokyo *et al.*, Toxic heavy metals cannot be degraded, but organic pollutants can be and are generally the major targets for phytoremediation. Phytoremediation processes rely on the ability of plants to take up and/or metabolize pollutants to fewer 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 their growth rate and biomass, their ability to tolerate and accumulate contaminants, the depth of their root zone, and their potential to transpire groundwater. Observation by Shivendra *et al.*, that in recent years, public concerns relating to ecological threats caused by heavy metal (HM) have led to intensive research of new economical plant-based remediation technologies. Conventional methods used for reclamation of contaminated soils, namely chemical, physical and microbiological methods, are costly to install and operate. The rapid increase in population coupled with fast industrialization growth causes serious environmental problems, including the production and release of considerable amounts of toxic waste materials into environment. Phytoremediation is a word formed from the Greek prefix "Phyto" meaning plant, and the Latin suffix "remedies" meaning to cure or restore. Although the term is a relatively recent invention, the practice is not. The use of plants to improve water quality in

municipal and more recently industrial water treatment systems, is well documented (8-9). Vegetation has long been used for the restoration of disturbed areas (1)9 and tolerant vegetation is often found on or planted into contaminated soils. There has also been the opportunity to Study the Kruger *et al.*; Phytoremediation of Soil and Water Contaminants ACS Symposium Series; American Chemical Society: Washington, DC, 1997. 1. CUNNINGHAM ETAL. Phytoremediation of Contaminated Water & Soil 5 plant-contaminant interactions that have resulted from the application of sewage sludge to land and from our 50 years of pesticide use. Given our strong agriculturally-based experience with planted soils and the more recent issues of environmental contamination, it is natural to explore the use of plants to remediate contaminated soils, aquifers, and wetland. Phytoremediation is popular because of its cost-effectiveness, aesthetic advantages, and long-term applicability. Applications include hazardous waste sites where other methods of treatment are too expensive or impractical, low-level contaminated sites where only "polishing treatment" is required over long periods of time, and sites where phytoremediation can be used in conjunction with other technologies as a final cap. Limitations of the technology include the potential for introducing the contaminant or its metabolites into the food chain, long clean-up times required to achieve regulatory action levels, and toxicity encountered in establishing and maintaining vegetation at waste sites. Plants have shown the capacity to withstand relatively high concentrations of organic xenobiotic chemicals without toxic effects. For metal contaminants, plants show the potential for phytoextraction (uptake and recovery of metals into above-ground biomass), filtering metals from water onto root systems or stabilizing wastes by hydraulic and erosional control at the site. Table 1 provides a summary of some phytoremediation applications and plants that have been used. A potential application of phytoremediation would be bioremediation of petrochemical spills and contaminated storage areas, ammunition wastes, fuel spills, chlorinated

solvents, landfill leachates, and agricultural nonpoint source runoff (i.e., pesticides and fertilizers). Generally, phytoremediation is used in conjunction with other clean-up approaches. Plants remediate organic pollutants via three mechanisms: direct uptake of contaminants and subsequent accumulation of nonphytotoxic metabolites into plant tissue; release of exudates and enzymes that stimulate microbial activity and biochemical transformations; and enhancement of mineralization in the rhizosphere (the root-soil interface), which is attributable to mycorrhizal fungi and the microbial consortia. It is also possible to concentrate metals in higher plants, and phytoremediation includes the use of plants to remediate sites contaminated by metals. However, in this article we focus on organic and nutrient pollutants. Vegetation offers other benefits at contaminated sites; phytoremediation increases the amount of organic carbon in the soil which, in turn, stimulates microbial activity. In addition, the establishment of deep-rooted vegetation helps to stabilize soil. When windblown dust is controlled, it reduces an important pathway for human exposure via inhalation of soil and ingestion of contaminated food. Plants also transpire considerable amounts of water. This loss of water can reverse the downward migration of chemicals by percolation and can lead to absorption of surface leachate. Researchers studying phytoremediation face some potential limitations. They still need to establish whether contaminants can collect in leaves and be released during litter fall or accumulate in fuelwood or mulch. It may be difficult to establish the vegetation because of soil toxicity or possible migration of contaminants off site by binding with soluble plant exudates.

Traditional methods of remediating contaminated soils, sediments, and groundwater are often based on civil and chemical engineering technologies that have developed over the last 20 years. These include a wide variety of physical, thermal, and chemical treatments, as well as manipulations to accelerate or reduce mass transport in the contaminated matrix. In certain cases, however, biological (especially microbial) processes have shown some applicability. Recent flexibility in the legal requirements associated with environmental clean-up has increased the acceptability of such "passive" approaches to remediation. In spite of this, a majority of the plans developed for site remediation do not rely on "natural attenuation". The reasons for this are clear. Engineering technologies are often faster, relatively insensitive to heterogeneity in the contaminant matrix, and can function over a wide range of oxygen, pH, pressure, temperature, and osmotic potentials. Biological processes are at a significant disadvantage in most of these areas. The perceived advantage of bioremediation is the often-prohibitive cost of effective engineering approaches. If remediation based on traditional technologies were inexpensive, there would appear to be no driving force for the development of alternative strategies based on biological activity. The elemental composition of normal soils is dependent on the geological and physical processes that occurred during its formation. Soils derived from marine sediments vary from those derived from rock outcroppings abundant in heavy metals. In addition to this inherent variability, anthropomorphic activities have increased soil heterogeneity. The most commonly cited sources of anthropogenic inorganic nontermination are the mining and smelting of metalliferous ore, fossil fuel handling and use,

industrial manufacturing, and the application of fertilizers and municipal sludges to land

Phytoremediation types

There are mainly six types

1. Phytosequestration

Also referred to as Phyto stabilization, there are many different processes that fall under this category. They can involve absorption by roots, adsorption to the surface of roots, or the production of biochemicals by a plant that is released into the soil or groundwater in the immediate vicinity of the roots and can sequester, precipitate, or otherwise, immobilize nearby contaminants.

2. Rhizodegradation

This process takes place in the soil or groundwater immediately surrounding the plant roots. Exudates (excretions) from plants stimulate rhizosphere bacteria to enhance biodegradation of soil contaminants.

3. Phytohydraulics

Use of deep-rooted plants—usually trees—to contain, sequester, or degrade groundwater contaminants that come into contact with their roots. For example, poplar trees were used to contain a groundwater plume of methyl-tert-butyl-ether (MTBE).

4. Phytoextraction

This term is also known as phytoaccumulation. Plants take up or hyper-accumulate contaminants through their roots and store them in the tissues of stems or leaves. The contaminants are not necessarily degraded but are removed from the environment when the plants are harvested.

This is particularly useful for removing metals from soil. In some cases, the metals can be recovered for reuse by incinerating the plants in a process called phytomining.

5. Phytovolatilization

Plants take up volatile compounds through their roots, and transpire the same compounds, or their metabolites, through the leaves, thereby releasing them into the atmosphere.

6. Phytodegradation

Contaminants are taken up into the plant tissues where they are metabolized, or biotransformed. Where the transformation takes place depends on the type of plant and can occur in roots, stems, or leaves.

Applications

Phytoremediation is usually applied to contaminated soil or water environments that are static in nature. Some of the examples include the restoration of abandoned metal mine workings and sites where polychlorinated biphenyls have been dumped during manufacture and mitigation of ongoing coal mine discharges reducing the impact of contaminants in soils, water, or air. Contaminants such as metals, pesticides, solvents, explosives, and crude oil and its derivatives, have been mitigated in phytoremediation projects worldwide. Many plants such as mustard plants, alpine pennycress, hemp, and pigweed have proven to be successful at hyperaccumulating contaminants at toxic waste sites. Not all plants are able to accumulate heavy metals or organics pollutants due to differences in the physiology of the plant.

Even cultivars within the same species have varying abilities to accumulate pollutants.

Disadvantages

- Accumulation of pollutant in fruit and other edible parts of crop and vegetables. So far growing of phytoremediator plants (hyperaccumulators)
- Low biomass production in phytoremediators, so several planting and harvesting required.
- Generally, specific selective unique accumulation of one metallic element in hyperaccumulator
- Handling and disposing contaminated plants through the phytoremediation is the major foot print of this green technology
- Mobilization of radionuclides through the translocation in plants.

Conclusion

These all methods are low cost and appropriate. That Phytoremediation is comprised of several different techniques that utilize vegetation, its related enzymes, and other complex processes. Collectively, these processes are able to isolate, destroy, transport, and remove organic and inorganic pollutants from contaminated media

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