

# Phyto Remediation- A Noval Approach To Decontaminate Soil Ecosystem

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## ABSTRACT

Soil ecosystem is a complex network of organisms and processes that interact to sustain life. It plays a crucial role in nutrient cycling, water filtration, and supporting plant growth, making it essential for terrestrial ecosystems and agriculture.

The main components of the Soil Ecosystem are soil organisms which includes microorganisms (Bacteria, fungi, protozoa, and nematodes are vital for decomposition, nutrient cycling, and soil health), invertebrates (Earthworms, beetles, and ants help aerate the soil, break down organic matter, and facilitate nutrient availability) and plants (Roots of which anchor soil and contribute organic matter through decaying leaves and other plant materials), Soil Structure, Nutrient Cycling, water, air and organic matter. Soil Ecosystem maintain plant Growth by providing essential nutrients and water to support plant life, carbon Sequestration in the soils by storing carbon, helping mitigate climate change by reducing release of greenhouse gases in the atmosphere and habitat supports for a diverse range of organisms.

Phytoremediation is an eco-friendly technology that uses plants to remove, transfer, stabilize, or destroy contaminants in soil and water. This method leverages the natural abilities of certain plants to absorb and detoxify pollutants, making it a sustainable alternative to traditional remediation techniques. This method can remove organic and inorganic contaminants in an effective manner. A variety of plant species are identified for phytoremediation. Various phytoremediation approaches like phytostabilization, phytoimmobilization and phytoextraction can be applied. However, the choice depends on various factors like contaminant mobility, climate conditions and soil physiochemical properties. In this paper some approaches and concerns related to phytoremediation are discussed.

**Keywords:** Phytoremediation, ecosystem, contaminants.

## INTRODUCTION

Phytoremediation is an eco-friendly technology that uses plants to remove, transfer, stabilize, or destroy contaminants in soil and water. This method leverages the natural abilities of certain plants to absorb and detoxify pollutants, making it a sustainable alternative to traditional remediation techniques. This method can remove organic and inorganic contaminants in an effective manner. A variety of plant species are identified for phytoremediation. Various phytoremediation approaches like phytostabilization, phytoimmobilization and

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Phytoremediation is process of growing the plants that can effectively accumulate, stabilize, extract or mobilize the contaminants in the soil. This technique can also be used to remove the unwanted salts from the soil. Flower et al (2010) in his paper Advances in understanding salt tolerance in plants: A review provides details of physiological, biochemical and molecular mechanism underlying salt tolerance in plants. He discussed the roles of ion transporters, osmoprotectants and stress responsive genes involved.

## **ROLES OF PHYTOREMEDIATION IN THE SOIL**

Phytoremediation involves the use of plants to clean up contaminated soil, water, and air. It is a noval approach of decontaminating the soil and prevent the contaminants to spread in the environment. Various roles of phytoremediation process in reclaiming the soil ecosystem are:

1. **Contaminant Uptake:** Phytoremediation process involve uptake of contaminants from the soil. Mail contaminants are heavy metala and some harmful organic contaminants. Some plants can absorb heavy metals from the soil, reducing their concentration and preventing them from entering the food chain and others can metabolize organic contaminants, breaking them down into less harmful substances.
2. **Soil Stabilization:** Soil stabilization is very important sustainable viability of the soil. It involves preventing soil erosion. Plant roots help anchor soil, reducing erosion and preventing the spread of contaminants. It also improves soil Structure. Root systems of plants possess symbiotic fungi which enhance soil aggregation and aeration, improving overall soil health.

3. **Enhancement of Microbial Activity:** As the phytoremediation process improve soil health through various methods, it enhance the microbial activities in the soils. Plants roots release organic compounds through, stimulating the growth of beneficial soil microorganisms that can degrade pollutants. Many plants form symbiotic relationships with mycorrhizal fungi and nitrogen fixing bacteria it can further enhance nutrient uptake and pollutant degradation.

4. **Phytostabilization:** Phytostabilization is an environmental remediation approach that uses plants to stabilize and contain contaminants in soil and water. This is to reduce the mobility and bioavailability of heavy metals and other pollutants, preventing them from spreading into surrounding areas and protecting the soil from unwanted contaminants. By binding contaminants in their roots and tissues, plants limit the bioavailability of these substances, thereby reducing their potential to leach into groundwater.

5. **Nutrient Cycling:** Nutrient cycling is a process of cycling the inorganic nutrients like carbon, nitrogen, sulphur etc. inbetween biotic and abiotic components. Plants can help cycle nutrients in the soil, making them available to other organisms and contributing to soil fertility over a long period of time.

6. **Carbon Sequestration:** It is a process of capturing and storing carbon dioxide from the atmosphere to reduce the amount of carbon in atmosphere and limit climate change. Biological carbon sequestration involve storing carbon in the plants twice as much as they emit. As the plants grow, they contribute organic matter to the soil, which can enhance its structure and fertility while sequestering carbon.

7. **Cost-Effective Solution:** Phytoremediation is a cost effective approach. Compared to conventional remediation methods, phytoremediation can be more cost-effective and requires less energy input.

Thus, phytoremediation plays a crucial role in restoring contaminated soils, promoting ecological health, and providing sustainable solutions for environmental cleanup.

## **FACTORS AFFECTING PHYTOREMEDIATION**

1. **Nature of Soil:** Soil structure is very important in phytoremediation process. In highly compacted soils the process of phytoremediation is hindered. Soil rich in organic matters enhances the process of phytoremediation.

2. **Soil pH:** Soil pH represent concentration of Hydrogen ions. Soil pH affects absorption of contaminants, phytostabilization and phytoextraction.

3. **Pollutants:** Pollutants present in the soil affect the process of phytoremediation. Phytoremediation basically involve removal of contaminants by absorption. The inorganic pollutants compete the process of absorption of other minerals including the contaminants.

4. Presence of Inorganic Fertilizers: Generally the inorganic fertilizers have positive impact on phytoremediation by promoting the plant growth. However, some inorganic nutrients may inhibit the process of phytoremediation. (Vinod kumar Cjhaudhary, july.2019).

## APPROACHES OF PHYTOREMEDIATION

Phytoremediation is an ecofriendly approach of decontaminating soils. It is a sustainable, cost effective and easy to use method. Various approaches of phytoremediation used by the plants are as follows:

### 1. Phytostabilization

Phytostabilization is an environmental remediation approach that uses plants to stabilize and contain contaminants in soil and water. This is to reduce the mobility and bioavailability of heavy metals and other pollutants, preventing them from spreading into surrounding areas and protecting the soil from unwanted contaminants.

#### Phytostabilization involve following steps:

1. Plant Selection: Certain plants are more effective at stabilizing contaminants. These may include hyperaccumulator plants which can tolerate and store heavy metals in their tissues especially in the vacuoles.
2. Root Systems: Roots possess a very large surface area. The roots of specific plants help to bind the soil and reduce soil erosion, which can prevent the spread of contaminants in the soil ecosystem.
3. Soil Improvement: Plants can improve soil texture and fertility over the time, helping to create a more stable environment.
4. Microbial Interactions: Plant roots can promote the growth of beneficial microbes that further assist in breaking down pollutants or stabilizing contaminants. Mycorrhizae help in this process.
5. Long-Term Solution: Phytostabilization can provide a more sustainable and cost-effective long-term solution compared to traditional methods like excavation or chemical treatment.

Method of phytoremediation is highly useful in the areas like mining sites which are affected by metal mpollution, landfill areas which helps to manage leachate and stabilize contaminated soils and agricultural Areas which are affected by pesticide and fertilizer overuse. However, this approach is highly time consuming, it just stabilize the contaminants and not remove the contaminants. Overall, phytostabilization is a promising strategy for managing contaminated lands in an eco-friendly manner.

## 2. Phytoextraction

In this phytoremediation method plants absorb contaminants, particularly heavy metals, from the soil and concentrate them in their tissues. Phytoextraction involves absorption of specific contaminant from the soil like heavy metals, uptake and accumulation of these contaminants in specific tissue like root, stem or leaves. After harvesting crop, the contaminants can be removed from the biomass which can then be disposed of safely or processed for metal recovery.

## 3. Phytovolatilization

Phytovolatilization is a phytoremediation process where plants take up volatile contaminants from the soil and water and release them into the atmosphere as vapor. This method is particularly effective for certain types of organic pollutants, such as volatile organic compounds (VOCs), including solvents and hydrocarbons. It work by uptake. Translocation and volatrization.It helps to remove harmful volatile compounds from contaminated environments, thereby reducing soil and water pollution.

However, phytovolatilization is affected by type of plant species as all plants are not effective in phytovolatilization. It also depends on the type of contaminant climate of the region.

## 4. Phytofiltration

Phytofiltration technique used by plants to filter and remove contaminants from water, particularly heavy metals and other pollutants. This method involves the absorption and accumulation of these substances by plant roots, making it an effective strategy for treating contaminated water sources. It also works by uptake, translocation, accumulation and harvesting.

Phytofiltration is commonly used in treating wastewater like sewage waters, runoff waters and water bodies contaminated by industrial discharges or agricultural runoff. It can be particularly useful in constructed wetlands where plants can naturally filter the water before it reaches larger natural ecosystems.

## 5. Phytodegradation:

Certain plants can break down organic pollutants through metabolic processes. This involves the plant enzymes converting harmful compounds into less toxic forms. It involves the breakdown of organic pollutants by plants through metabolic processes. This technique can effectively degrade a variety of contaminants, including pesticides, solvents, and other organic compounds, making it a valuable method for soil and water remediation. Once degraded, compounds may be stored in plant tissues or further broken down by the plant metabolic pathways. Agricultural lands contaminated with pesticides can be effectively reclaimed through phytodegradation

## Techniques/Process of Phytoremediation

Different plant uses different methods or their combination with other methods for decontamination of soil and water depending upon the types of contaminant, forms, and the medium. Soil contaminants are removed through phytoextraction, phytodegradations, phytostabilization, phytomobilization, rhizodegradation and phytovolatilization.

Plant species selected for phytoremediation should be hardy, easily cultivable, sufficiently tolerable to contaminant stresses, capable of producing high biomass, can efficiently absorb the contaminants etc.

## CONCLUSION

1. Phytoremediation is an eco-friendly technology that uses plants to remove, transfer, stabilize, or destroy contaminants in soil and water. This method leverages the natural abilities of certain plants to absorb and detoxify pollutants, making it a sustainable alternative to traditional remediation techniques. Phytoremediation is a cost-effective alternative to traditional remediation methods, promoting ecological restoration and enhancing biodiversity. It is a sustainable technique. Phytoremediation researches should involve modern techniques of biotechnology where the plants can be genetically modified to increase in the efficiency of phytoremediation in the plants. Phytostabilization can provide a more sustainable and cost-effective long-term solution compared to traditional methods like excavation or chemical treatment. As it involves diverse approaches of phytoremediation can be plasticized for a variety of contaminants.

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