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Phytoremediation: A Novel Technology for Removing Contaminants from Polluted Lands

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ARTICLE ID: 60

Introduction

Groundwater, land, and surface water contamination have increased significantly over the past few decades, as has global pollution levels. Toxic effluents discharged from a variety of sources, including industrial, household, technical, agricultural, and medical waste, are to blame for the global trend of rising pollution levels. Lack of awareness and correct understanding among the populace, which results in inappropriate management and disposal, is a significant contributor to this widespread contamination. The build-up of pollutants, such as metals, radioactive materials, and organic residues, disrupts the ecosystem and has a negative effect on the quality of natural resources. Synthetic remediation methods not only damage the soil micro biota but also render the soil unusable for farming and, most of the time, fail to completely remove the toxins from the soil. Consequently, there is a growing need to create and implement alternative, eco-friendly technology and phytoremediation is one such remediation technology.

For treatment of contaminated soils, phytoremediation makes use of the inherent capabilities of plants and the microorganisms that are associated with them. It is a rapidly developing technology that has the ability to effectively and affordably remove a wide variety of organic and inorganic wastes. It has been determined through a number of research, evaluating the fundamental aspects of phytoremediation that some plant species naturally have the capacity to absorb, immobilise, degrade, or metabolise pollutants.

Phytoremediation

In phytoremediation, contaminated groundwater, soil, and wastewater are cleaned up using plants. The method known as "phytoremediation" uses green plants, such as grasses, ferns, and woody species, to remediate, remove, immobilise, or change environmental pollutants, such as heavy metals, organic compounds, and other components in natural

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resources. It may be used to treat both organic and inorganic toxins found in soil or water, and because it is driven by solar energy, it is more affordable and environmentally beneficial than any other detoxification technique. The phytoremediation strategy necessitates cultivating plants there for a specific period of time and desirable growth stage in order to remove pollutants from a contaminated site or to enable the immobilisation (binding) or destruction (decontamination) of the contaminants there and the resultant plants are gathered, processed, and properly disposed of.

Mechanisms of phytoremediation:

Phytoremediation is a fast and continuously developing field of technology that makes use of particular plants to purge the environment of dangerous toxins with the goal of improving the quality of the environment. This technology is divided into different types depending upon the type of mechanism involved in the pollutant removal process as shown in Fig 1.

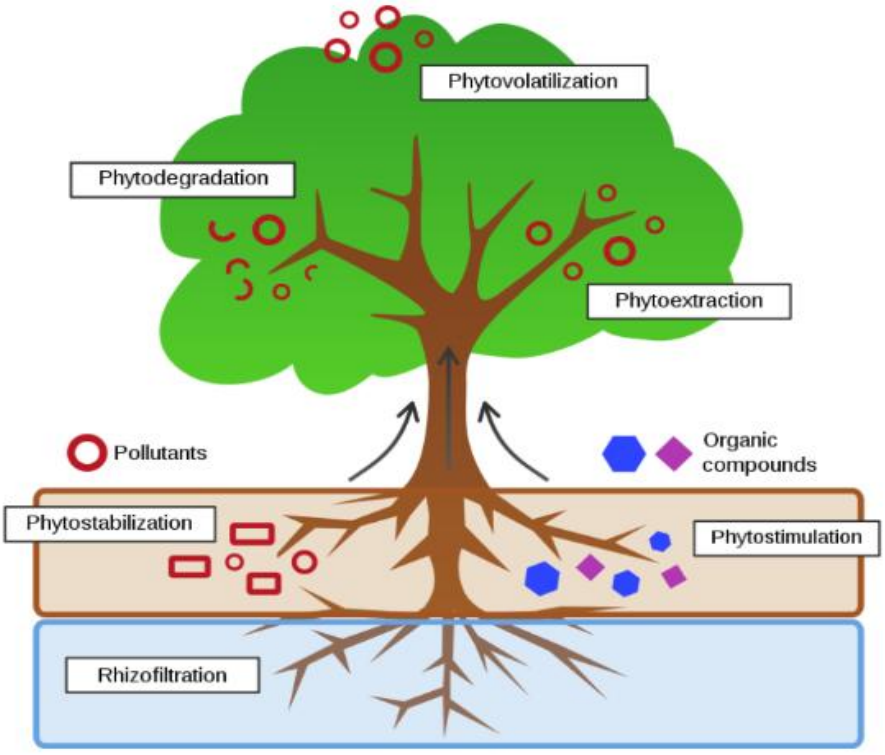

Fig 1: Mechanisms of phytoremediation (Tang, 2019)

(1) Eliminating pollutants from the soil by accumulating them in above ground plant parts (phytoextraction),

(2) Detoxification of pollutants inside the tissues of plants (phytodegradation)

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(3) Limiting the movement of pollutant in the soil (phytostabilization)

(4) Liberation of pollutants in the environment through transpiration mechanism of plants (phytovolatilization),

(5) Increasing the activities of soil microbiota for the efficient removal of pollutants by plants in the rhizospheric region (phytostimulation), and

(6) Uptake of pollutants by the root zone of the plant (rhizofilteration)

Types of Plants to Be Used

Ideal plant species for phytoremediation purpose should be:

- Hardy in nature
- High biomass-producing
- Tolerant to toxic effects of metals and contaminants
- Easy to cultivate
- High absorption capacity
- on-attractive for herbivory

Disposal of Contaminated Biomass

- The following are the primary alternatives for disposing of contaminated biomass that was obtained during a phytoremediation like ashing, liquid extraction, pyrolysis, leaching, composting, direct disposal etc (Ghosh and Maiti, 2020).

Advantages

- The cost of the phytoremediation is lower than that of traditional processes both *in situ* and *ex situ*
- The plants can be easily monitored
- The possibility of the recovery and re-use of valuable metals (by companies specializing in "phyto mining")
- It is potentially the least harmful method because it uses naturally occurring organisms and preserves the environment in a more natural state.
- Applicable for variety of compounds
- Environmental friendly
- Cost-effective

Limitations

- Phytoremediation is limited to the surface area and depth occupied by the roots.

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- Slow growth and low biomass require a long-term commitment
- With plant-based systems of remediation, it is not possible to completely prevent the leaching of contaminants into the groundwater (without the complete removal of the contaminated ground, which in itself does not resolve the problem of contamination)
- The survival of the plants is affected by the toxicity of the contaminated land and the general condition of the soil.
- Bio-accumulation of contaminants, especially metals, into the plants which then pass into the food chain

Conclusions

Due to its efficiency and use of environmentally benign techniques to clean up pollutants in soil, water, and the air, phytoremediation is a sustainable technology. Through a variety of methods, including phytoextraction, phytostabilization, rhizofiltration, phytovolatilization, phytodegradation, and phytodesalination, this technology uses plants to remove environmental pollutants from the environment. It can be used to clean up a variety of contaminants both organic as well as inorganic. Nevertheless, depending on the impurities being remedied, plants have varying capacities. Therefore, it is important to choose plants based on the pollutants and site circumstances.

Future Thrust

- Limited knowledge about transgenic plants
- Less public acceptance, so quantification of economical data is needed

References

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