CHANNABASAVESHWARA INSTITUTE OF TECHNOLOGY

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(NAAC Accredited & ISO 9001:2015 Certified Institution)

“PHYTOREMEDIATION”

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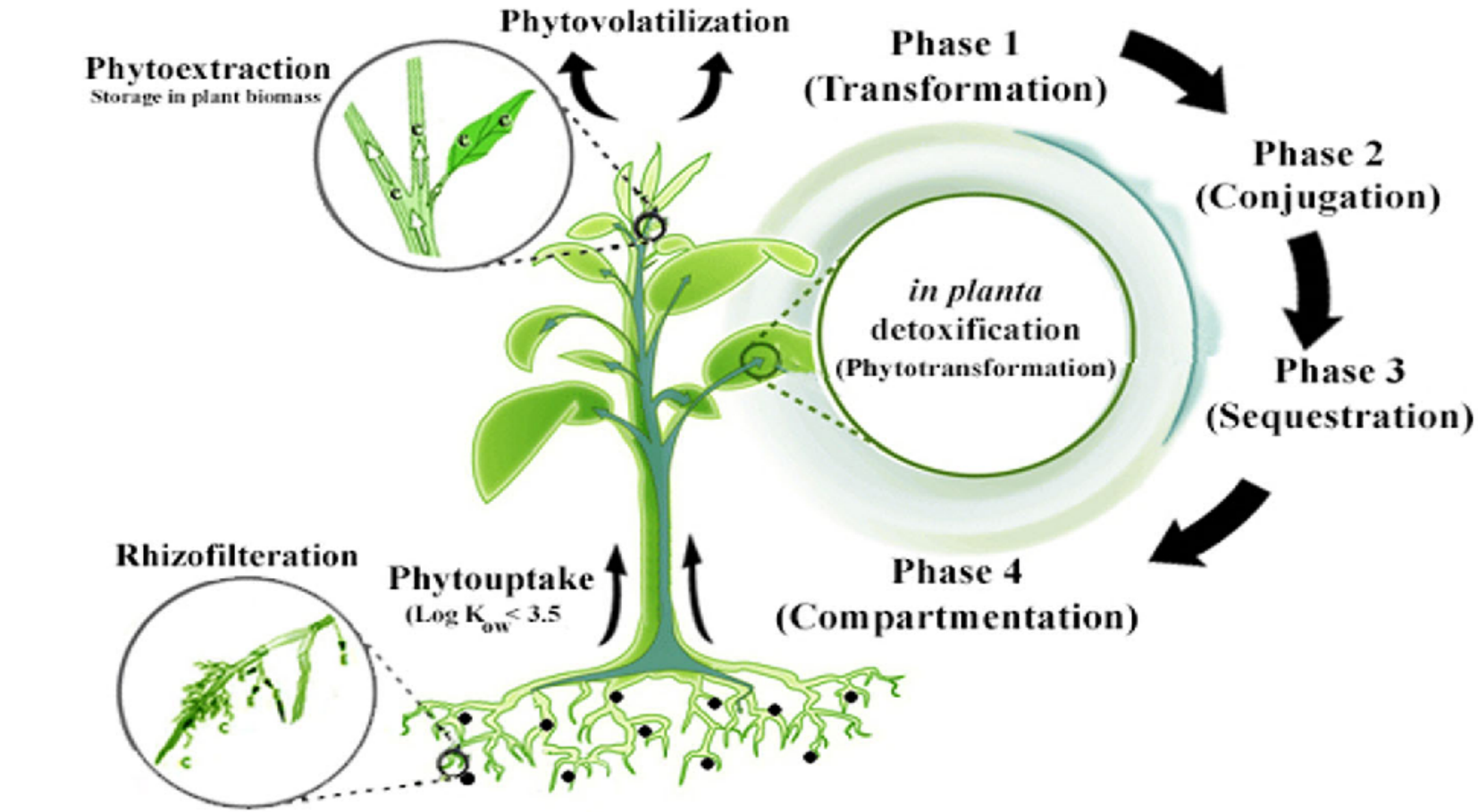
PHYTOREMEDIATION



- Pollutant

in planta detoxification + Endophytic degradation = Enl

INTRODUCTION

PHYTOREMEDIATION

- Phyto = plant, and remedium = restoring balance.
- Defined as “the efficient use of plants to remove, detoxify or immobilize environmental contaminants in a growth matrix (soil, water or sediments) through the natural biological, chemical or physical activities and processes of the plants”
- The process of phytoremediation is based on three key mechanisms

  - Extraction
  - Confinement
  - Degradation

HOW DOES PHYTOREMEDIATION WORK ?

- Phytoremediation is an in-situ remediation technology that utilizes the inherent abilities of living plants.

- The mechanisms and efficiency of phytoremediation depend on the type of contaminant, bioavailability and soil properties.

- The root system provides an enormous surface area that absorbs and accumulates the water and nutrients essential for growth, as well as other non-essential contaminants.

LITRATURE REVIEW

SLNO	Title of the paper	Author's name	Summary
1	Introduction to phytoremediation- a green clean technology	DR (Mrs) Jot Sharma	Phytoremediation has been perceived to be a more environmentally-friendly "green" and low tech alternative to more active and intrusive remedial methods.
2	Accumulation and distribution of lead (Pb) in plant tissues of guar (Cyamopsis tetragonoloba L.) and sesame (Sesamum indicum L.): profitable phytoremediation with biofuel crops	Hira Amin, Basir Ahmed Arain, Taj Muhammad Jahangir, Muhammad Sadiq Abbasi , Farah Amin	The harvested biomass could then be incinerated and disposed off or the accumulated metal could also be recovered for commercial uses and thus reused as biofuel.
3	Mechanistic understanding and holistic approach of phytoremediation: A review on application and future prospects	Krishna Kumar Yadava, Neha Guptaa , Amit Kumarb , Lisa M. Reecec , Neeraja Singhd , Shahabaldin Rezaniae , Shakeel Ahmad Khanf	Plant breeders, biotechnologists, physiologists, agronomists soil scientists, biochemists and environmentalists must work together to generate solid approaches to develop transgenic plants and enhance the potential of existing crop species to perform better remediation activities of metal toxins.
4	Phytoremediation: sustainable approach for the removal of Heavy	Subbulakshmi Ganesan , Sagnika Panda, Anjali Sinha	For commercialization, the plants need to be tested in the field for phytoremediation efficiency. Identification of desirable traits in natural hyper accumulator's selection and breeding

SUMMARY OF LITERATURE REVIEW

- Phytoremediation has been perceived to be a more environmentally-friendly “green” and low tech alternative to more active and intrusive remedial methods. In conclusion, there are real risks associated with phytoremediation that require assessment and identification of management options prior to implementation of any field based operations.

- The harvested biomass could then be incinerated and disposed off or the accumulated metal could also be recovered for commercial uses and thus reused as biofuel.

- Plant breeders, biotechnologists, physiologists, agronomists soil scientists, biochemists and environmentalists must work together to generate solid approaches to develop transgenic plants and enhance the potential of existing crop species to perform better remediation activities of metal toxins.

- For commercialization, the plants need to be tested in the field for phytoremediation efficiency. Identification of desirable traits in natural hyper accumulator’s selection and breeding techniques should be done and these different desirable traits can be combined into a single plant species.

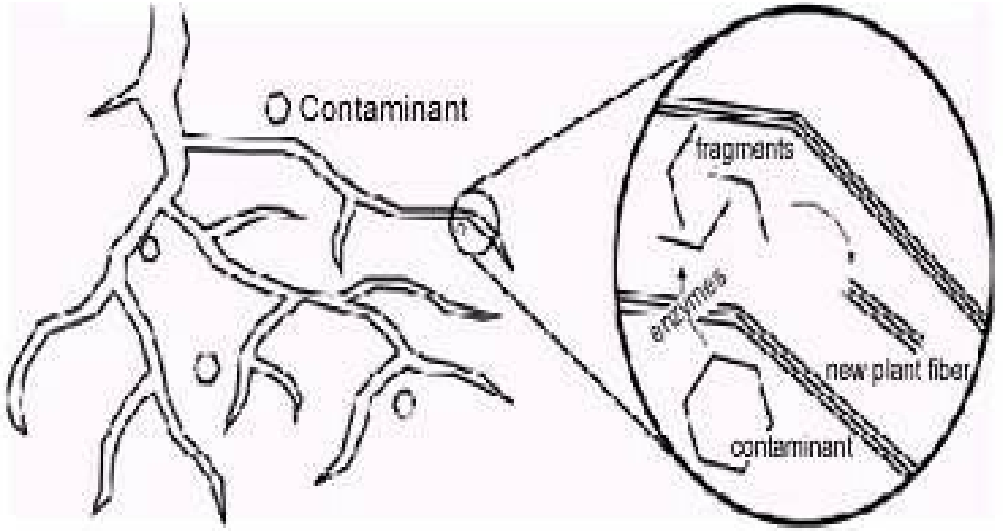
APPLICATIONS

THE USE OF PHYTOREMEDIATION TO TREAT ORGANIC CONTAMINANTS

- Phytodegradation
- Rhizodegradation
- Phytovolatilization

1.PHYTODEGRADATION

- Also called as Phyto transformation
- degradation of complex organic molecules to simple molecules or the incorporation of these molecules into plant tissues
- Plants contain enzymes that catalyze and accelerate chemical reactions. Uptake of contaminants depend on hydrophobicity, solubility and polarity.
- Enzymes in plant roots break down (degrade) organic contaminants. The fragments are incorporated into new plant material.



Examples:

1.Trichloroethylene(TCE),a prevalent ground water contaminant,

Transformed to less toxic metabolites by using hybrid popular tree.

2.Phytodegradation has been observed to remediate some organic contaminants, such as chlorinated solvents, herbicides, and munitions, and it can address contaminants in soil, sediment, or groundwater .

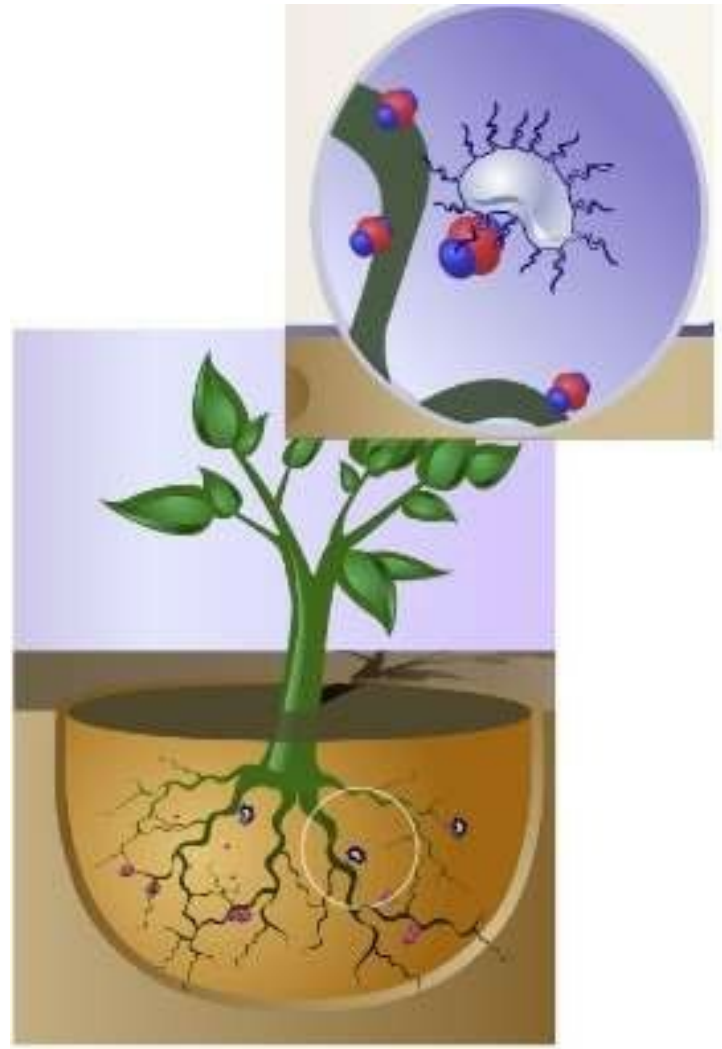
3.Atrazine in soil was taken up by trees and then hydrolyzed and dealkylated within the roots, stems, and leaves.

2.RHIZODEGRADATION

- Also called Phyto stimulation or plant assisted bioremediation/degradation.
- Symbiotic relationship
- Natural substances released by the plant roots – sugars, alcohols, and acids – contain organic carbon that provides food for soil microorganisms and the additional nutrients enhance their activity
- Additionally, the rhizosphere substantially increases the surface area where active microbial degradation can be stimulated.

- Example :
- The number of beneficial bacteria increased in the root zone of hybrid poplar trees and enhanced the degradation of BTEX, organic chemical, in soil.

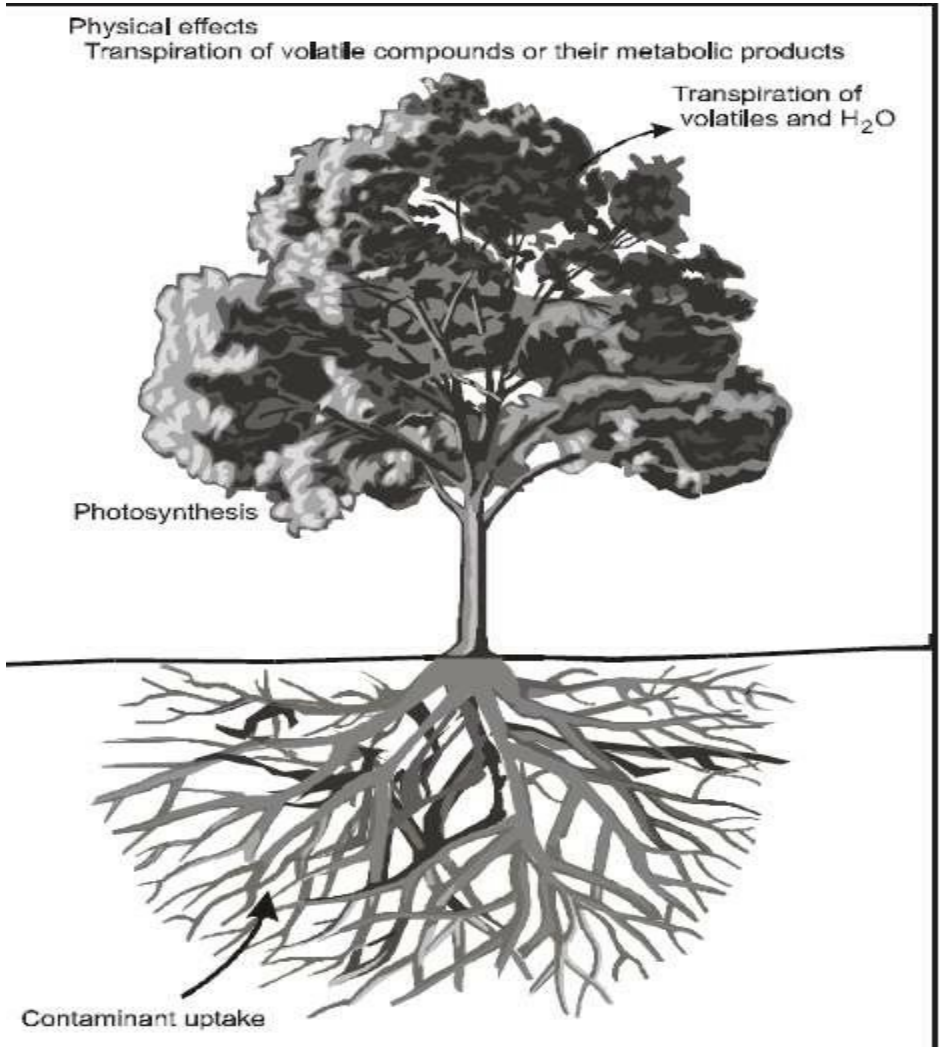
- Phytoremediation was able to bring TPH levels and PAH levels to below the plateau level found with normal (non-plant-influenced) bioremediation.



3.PHYTOVOLATILIZATION

- Uptake and transpiration of a contaminant by a plant, with release of the contaminant or a modified form of the contaminant from the plant to the atmosphere.
- Phytovolatilization has mainly been applied to groundwater, but it can be applied to soil, sediments, and sludges.
- Example : Poplar trees at one particular study site have been shown to volatilize 90% of the TCE they take up.

- Because phytovolatilization involves the transfer of contaminants to the atmosphere , the impact of this contaminant transfer on the ecosystem and on human health needs to be addressed.
- Climatic factors such as temperature, precipitation, humidity, insolation, and wind velocity can affect transpiration rates.

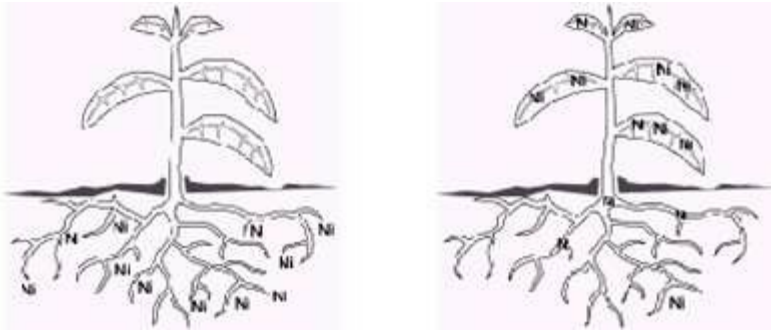


THE USE OF PHYTOREMEDIATION TO TREAT METAL CONTAMINANTS

- Phytoextraction
- Rhizofiltration
- Phyto stabilization

1.PHYTOEXTRACTION

- Also called phytoaccumulation, refers to the uptake of metals from soil by plant roots into above-ground portions of plants.
- Certain plants, called hyperaccumulators, absorb unusually large amounts of metals in comparison to other plants. Eg .*Thlaspi rotundifolium*
- After the plants have been allowed to grow for some time, they are harvested and either incinerated or composted to recycle the metals.
- Benefit is that the contaminant is permanently removed from the soil.



Uptake of metals(nickel) by phytoextraction

Example :

1.Detroit lead contaminated site was removed with Sunflower and Indian Mustard.

2.Arsenic, using the Sunflower, or the Chinese Brake fern , a hyperaccumulator. Chinese Brake fern stores arsenic in its leaves.

3.Mercury, selenium and organic pollutants such as polychlorinated biphenyls (PCBs) have been removed from soils by transgenic plants .

2.RHIZOFILTRATION

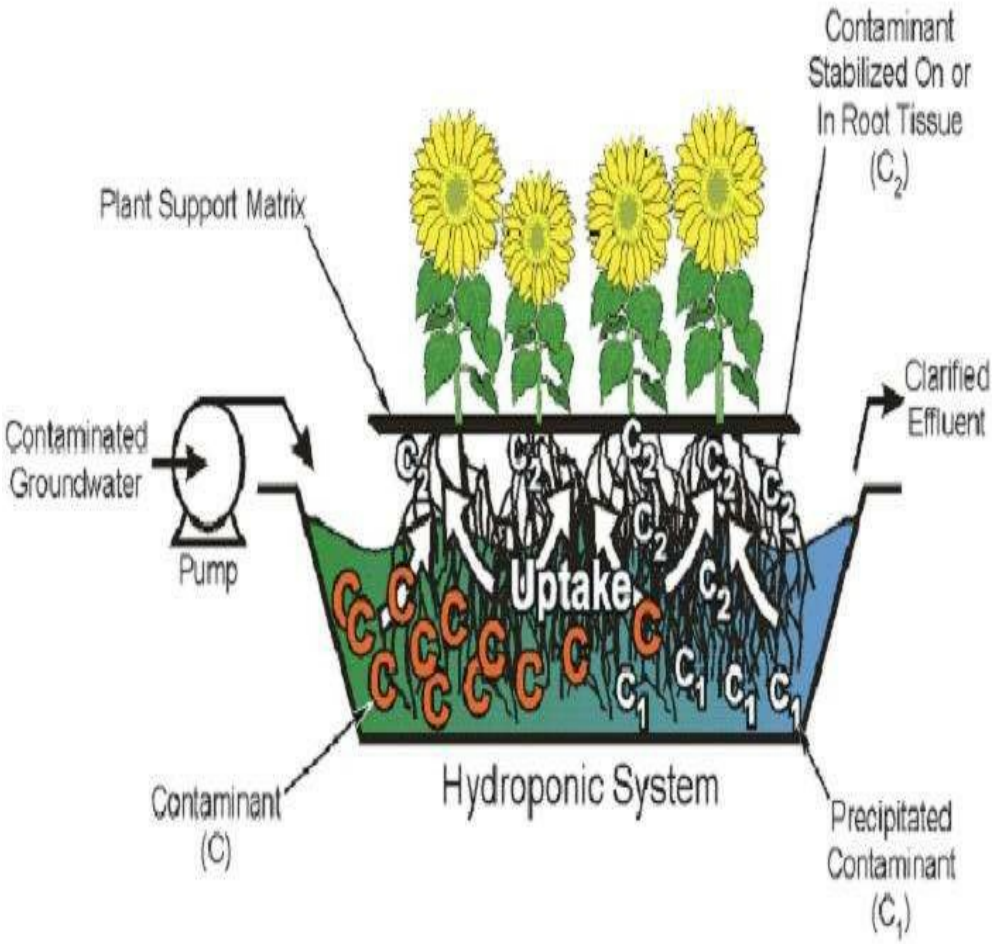
- Rhizo means root
- Adsorption or precipitation onto plant roots, or absorption into the roots of contaminants that are in solution surrounding the root zone, due to biotic or abiotic processes.
- Exploited in groundwater, surface water, or wastewater for removal of metals or other inorganic compounds.
- Rhizofiltration first results in contaminant containment, in which the contaminants are immobilized or accumulated on or within the plant. Contaminants are then removed by physically removing the plant.

Examples :

1. Sunflower, Indian mustard, tobacco, rye, spinach, and corn have been studied for their ability to remove lead from water, with sunflower having the greatest ability.

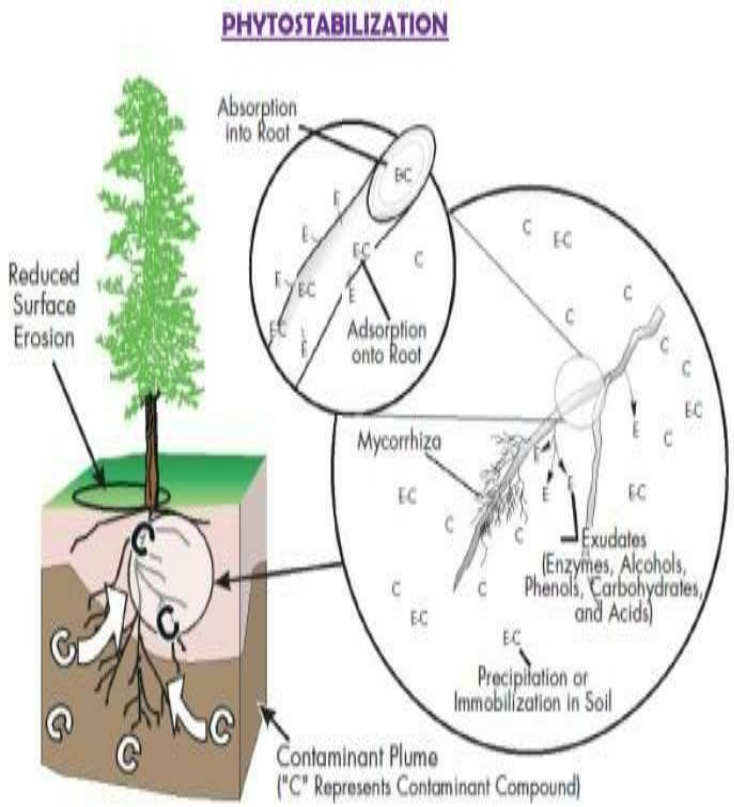
Sunflowers were successfully used to remove radioactive contaminants from pond water in a test at Chernobyl, Ukraine.

2.Rhizofiltration can be used for Pb, Cd, Cu, Ni, Zn, and Cr, which are primarily retained within the roots.



3.PHYTOSTABILIZATION

- This is also referred to as in-place inactivation.
- Phytostabilisation is the use of certain plant species to immobilize contaminants in the soil and groundwater through absorption and accumulation by roots, adsorption onto roots, or precipitation within the root zone of plants (rhizosphere)
- It is primarily used for the remediation of soil, sediment, and sludge.
- Reduces mobility and prevents migration.



- Change in pH , metal solubility and mobility
- Used to re establish vegetation cover at sites where natural vegetation fails to survive due to high metals concentrations in surface soils or physical disturbances to surface materials.
- Advantages is that the disposal of hazardous material/biomass is not required and very effective when rapid immobilization is needed to preserve ground and surface waters.
- Example : Phyto stabilization using metal-tolerant grasses is being investigated for large areas of Cd- and Zn-contaminated soils at a Superfund site in Palmerton, PA.

THE USE OF PHYTOREMEDIATION FOR HYDRAULIC CONTROL OF CONTAMINANTS

- Also known as Phyto hydraulics or hydraulic plume control.
- Hydraulic control is the use of plants to remove groundwater through uptake and consumption in order to contain or control the migration of contaminants.
- use phreatophyte trees and plants that have the ability to transpire large volumes of water eg . Poplar tree can transpire between 50 and 300 gallons of water per day out of the ground.
- Reduces infiltration of precipitation and reducing contaminant migration
- The primary considerations for selecting hydraulic control as the method of choice are the depth and concentration of contaminants that affect plant growth.
- Soil texture and degree of saturation are influential factors.

ADVANTAGES

- “nature” method, more aesthetically pleasing.
- 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
- Minimal land disturbance.
- Reduces potential for transport of contaminants by wind, reduces soil erosion
- Hyperaccumulators of contaminants mean a much smaller volume of toxic waste.
- Multiple contaminants can be removed with the same plant.

DISADVANTAGES

- Limited to the surface area and depth occupied by the roots.
- Slow growth and low biomass require a long-term commitment
- Not possible to completely prevent the leaching of contaminants into the groundwater
- 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, from primary level consumers upwards and/or requires the safe disposal of the affected plant material.

CASE STUDY

- **Ashley Marie Stiffarm. Phytoremediation of soil contamination B.S. Haskell Indian Nations University, 2015**
- Contaminated water is a major source of environmental and human health problems that can be remedied by utilizing the growing phytoremediation technology
- The Biosolids Farm of Manhattan, Kansas, is located near Manhattan, Kansas, and provides the emerging technology of phytoremediation.
- This planting was done to act as a vegetative barrier and to aid in nitrate reduction in the river.
- With the inclusion of compost and shelters, the treatments revealed vital interactions with tree sources with a p-value of 0.0438, and trenching and compost with a p-value of 0.0021. The use of tree shelters increased tree survival by a significant amount.

- **Nzengung V. A., Wolfe, L.N., Rennels, D., McCutcheon, S.C. 1999. Use of aquatic plants and algae for decontamination of waters polluted with chlorinated alkanes, *Intern. J. Phytoremediation*, vol. 1, no. 3, pp. 203-226.**

- Dead plants were used in experiments to indirectly test the idea that dead aquatic plants retain and maybe contribute to the dehalogenase activity found in organic-rich sediments.
- After the aquatic plants and algae were exposed to HCA- and CT-dosed solutions, a quick action stage was followed by a gradual change lasting many hours.
- The metabolic activity of dead plants and algae suggests that photoautotrophs sustain this activity after death, and so the active agents may get bound to the sediment-organic matrix as plants die, rot, and are buried
- The findings of tFresh plants that were stressed, axenic, and physiologically healthy all reformed the two chlorinated alkanes and produced identical breakdown products.
- his study suggest that removing chlorinated alkanes from water and restoring aquatic ecosystems can improve the quality of aquatic plants and fresh algae.

INFERENCE

- Phytoremediation will undoubtedly play a part in the stability and remediation of many polluted sites, even though much more research is needed.
- Low costs combined with considerable improvements in site aesthetics and the potential for ecosystem restoration drive the development of phytoremediation projects.
- Whether the technique is efficient in removing pollution, the presence of trees improves the ecosystem.

REFERENCE

- Nzengung, V. A., Wolfe, L.N., Rennels, D., McCutcheon, S.C. 1999. Use of aquatic plants and algae for decontamination of waters polluted with chlorinated alkanes, *Intern. J. Phytoremediation*, vol. 1, no. 3, pp. 203-226.
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Thank You

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