



**Phytoremediation: A Green Technology  
to clean the environment**

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Phyto = plant, and remediation = 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”

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## Factors of Phytoremediation

Plants have the capacity to uptake, degrade, transform, sequester contaminants in addition to producing biomass.

- Site characteristics and contaminant type
- Plant species
- Levels of contamination
- Contaminated area - size and depth
- Site conditions (nutrient availability, soil organic matter content, soil water, soil aeration).
- Ability to extract or degrade the contaminants of concern
- Ability to take up large quantities of water through the roots
- generally more effective when using large, fast-growing plants (e.g) poplar trees.

## TOP 5 phytoremediators...

**Indian mustard** *Brassica juncea*



**White Willow**



**Poplar tree** *Populus deltoides*



**Indian grass** *Sorghastrum nutans*



**Sunflower** *Helianthus annuus*

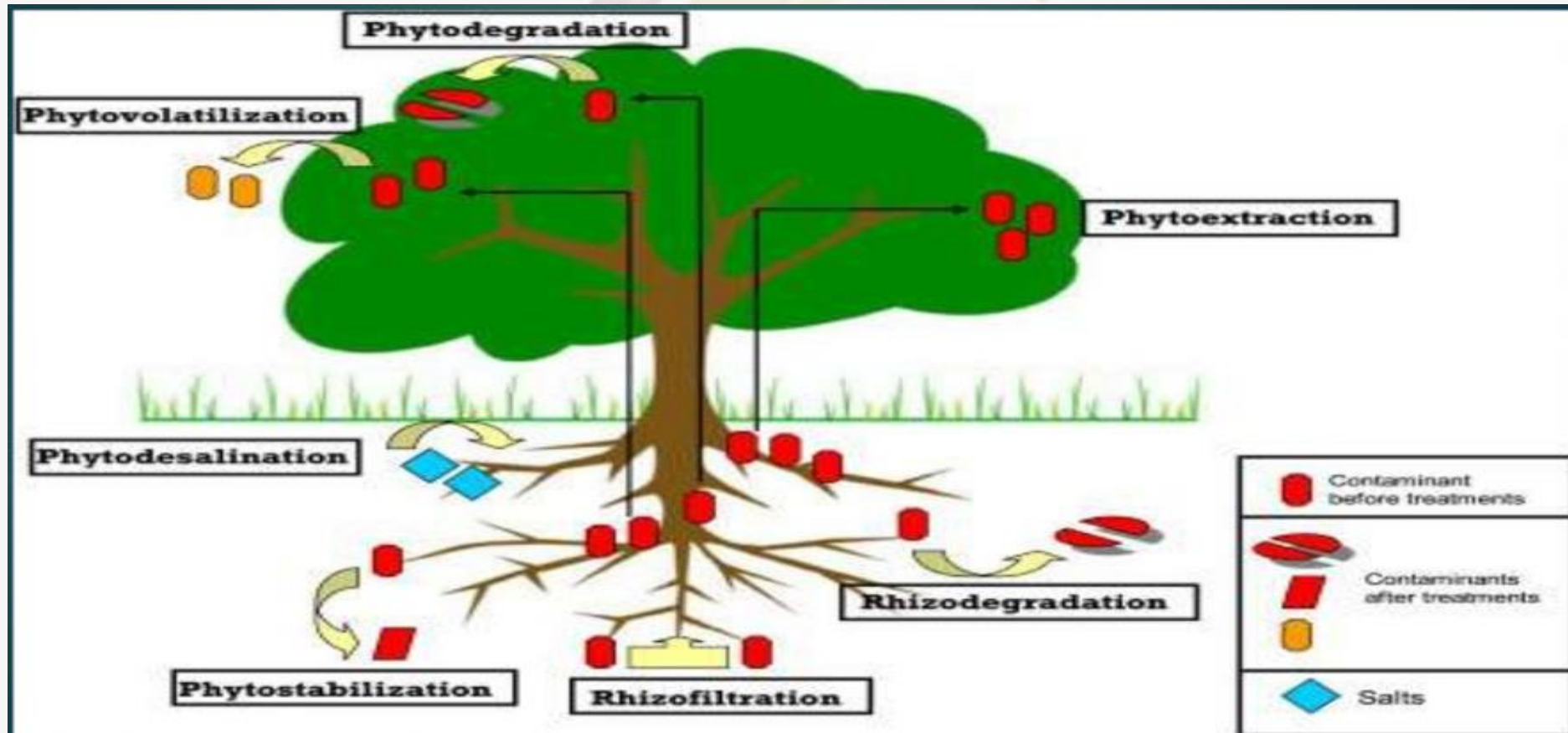


## HOW DOES PHYTOREMEDIATION WORK ?

- Phytoremediation is an in situ remediation technology utilizes the inherent abilities of living plants.
- The mechanisms and efficiency of phytoremediation depend on the type of contaminant, bioavailability and properties.
- The root system provides an enormous surface area that absorbs and accumulates the water and nutrients for growth, as well as other non-essential contaminants.



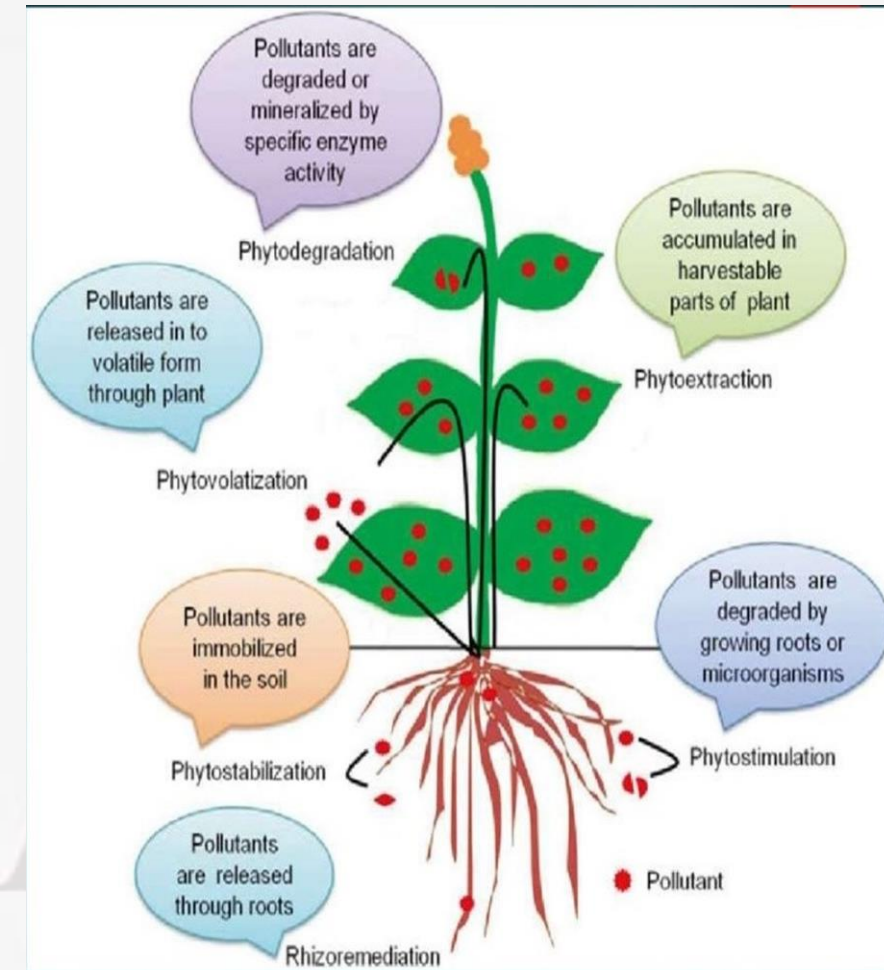
## Forms of Phytoremediation



Source: <https://en.wikipedia.org/wiki/Phytoremediation>

## Various phytoremediation processes

- Phytoextraction
- Phytostabilization
- Phytotransformation
- Phytostimulation
- Phytovolatilization
- Rhizofiltration



[https://www.researchgate.net/figure/Schematic-diagram-of-different-approaches-of-phytoremediation\\_fig3\\_268148634](https://www.researchgate.net/figure/Schematic-diagram-of-different-approaches-of-phytoremediation_fig3_268148634)

## **THE USE OF PHYTOREMEDIATION TO TREAT ORGANIC CONTAMINANTS**

- Phytodegradation
- Rhizodegradation
- Phytovolatilization

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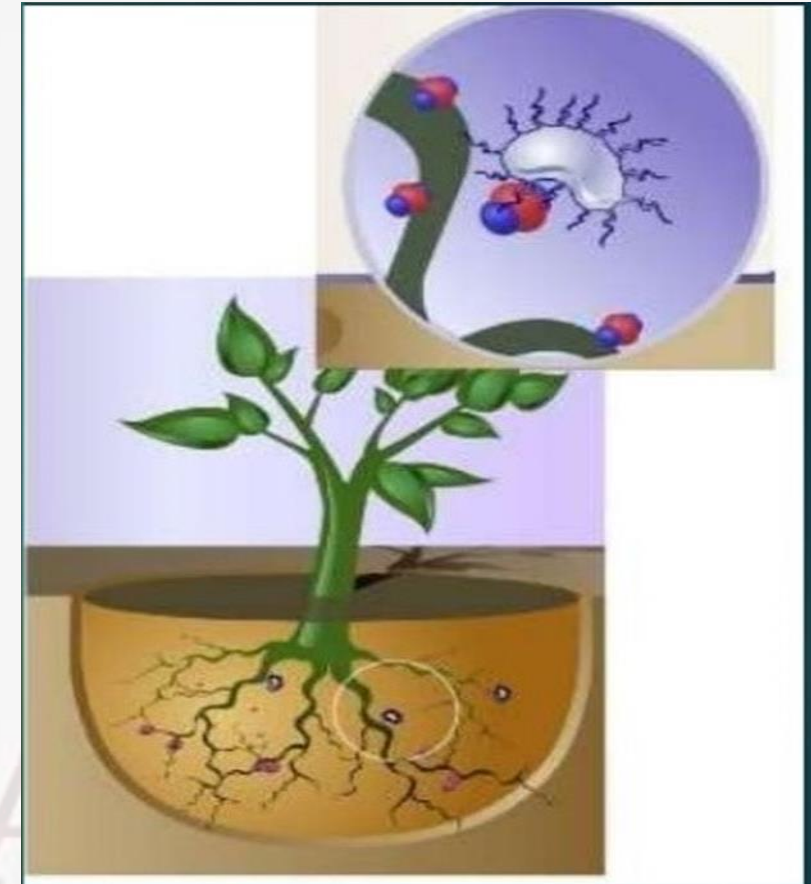
## Phytodegradation

- Also called as Phytotransformation.
- Degradation of complex organic molecules to simple molecules or the incorporation of these molecules into tissues.
- Plants contain enzymes that catalyze and accelerate reactions.
- Uptake of contaminants depend on hydrophobicity, solubility and polarity.

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## RHIZODEGRADATION

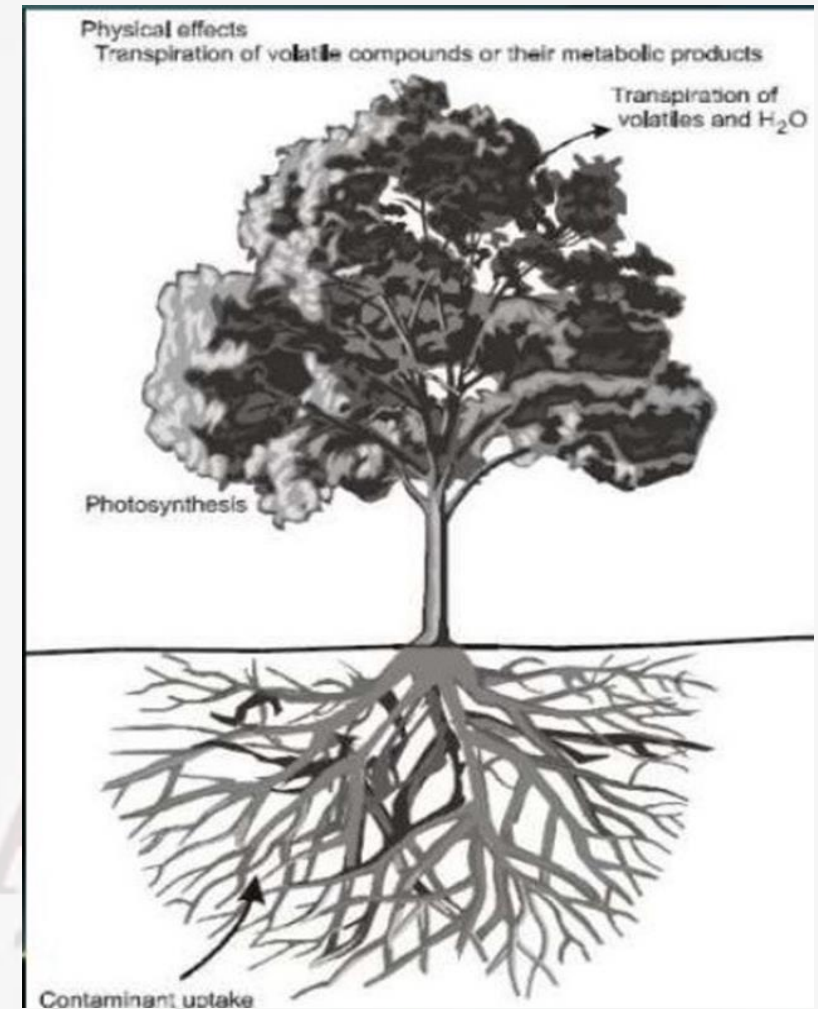
- Also called phytostimulation or plant assisted bioremediation/degradation.
- Symbiotic relationship
- Natural substances released by the plant roots — sugars, alcohols, and acids — contain organic carbon that food for soil microorganisms and the additional nutrients enhance their activity.
- Additionally,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



[https://www.slideshare.net/Christa\\_belle/phytoremediation-43828173](https://www.slideshare.net/Christa_belle/phytoremediation-43828173)

## 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 Sludge. Ex: Poplar trees.



<https://pubs.acs.org/doi/pdf/10.1021/acs.est.5b04113>

- 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.
- Climate factors such as temperature, Precipitation, humidity, insolation, and wind velocity can affect transpiration rates.

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## **THE USE OF PHYTOREMEDIATION TO TREAT METAL CONTAMINANTS**

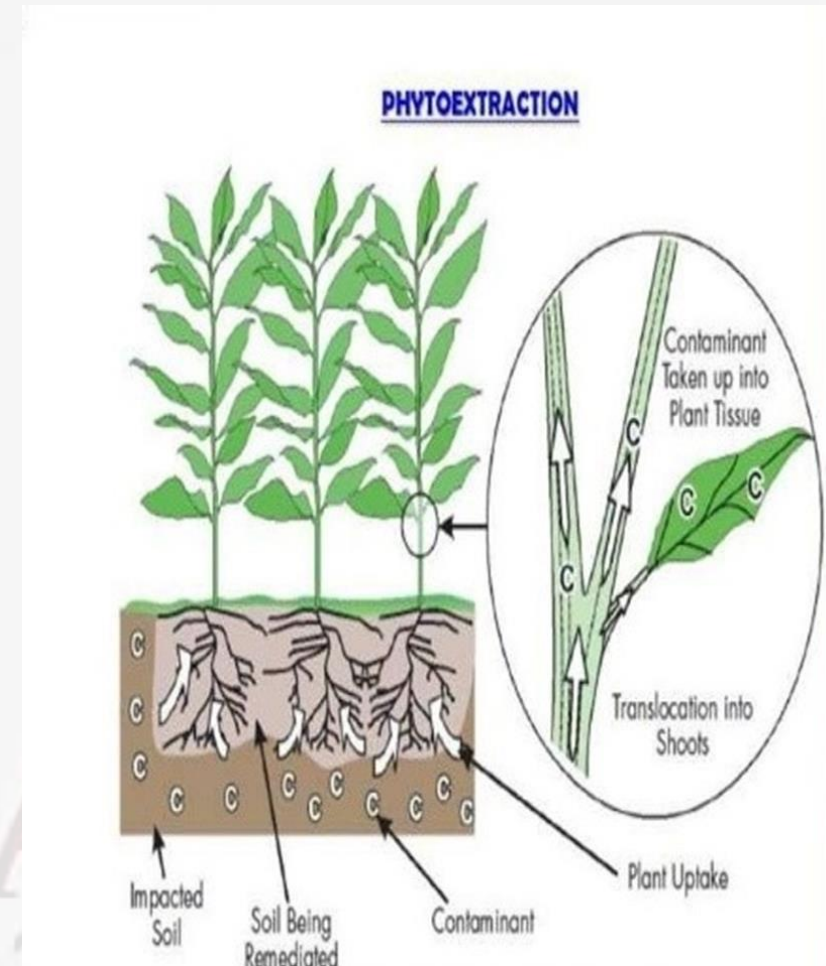
- Phytoextraction
- Rhizofiltration
- Phytostabilization

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## 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. Example: *Thlaspi rotundifolium*.



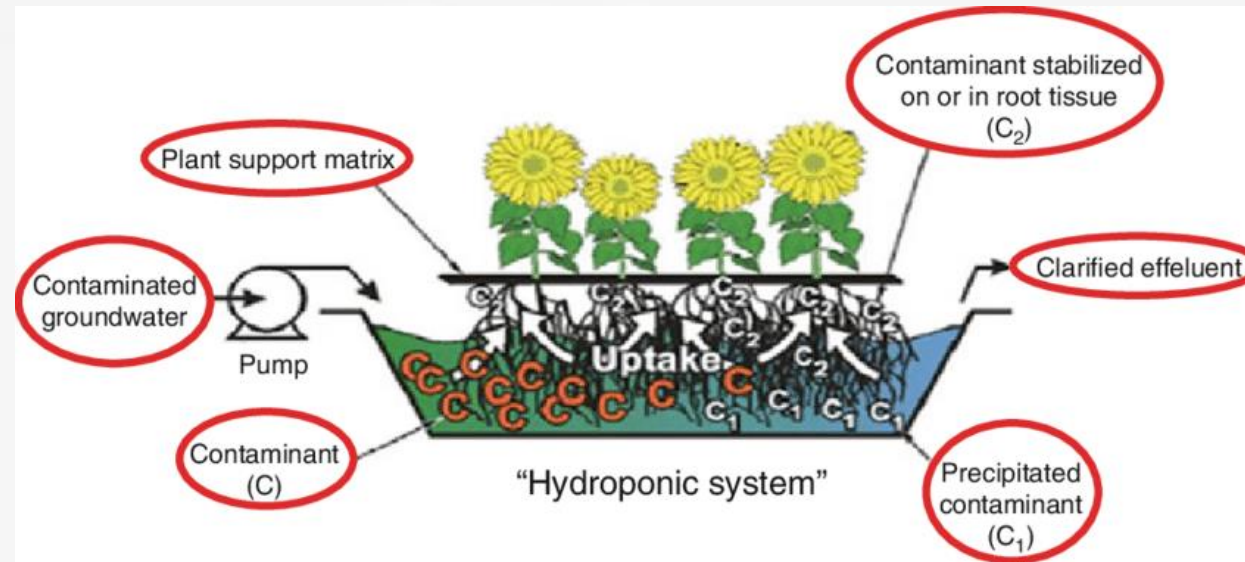
<https://knowhowtogmo.wordpress.com/2011/01/31/phytoextraction/>

- 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.
- Detroit lead contaminated site was removed with Sunflower and Indian Mustard.
- Arsenic, using the Sunflower, or the Chinese Brake fern, a hyperaccumulator.
- Mercury selenium and organic pollutants such as polychlorinated biphenyls(PCBs) have been removed from soils transgenic plants.

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## **RHIZOFILTRATION**

- Rhizo means root.
- Adsorption or precipitation onto plant roots, or 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.



**Source: <https://present5.com/phytoremediation-introduction-q-phytoremediation-is-the-use/>**

## Examples

- 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, Pb, Cd, Cu, Ni, Zn, and Cr, which are primarily retained within the roots.

## **PHYTOSTABILIZATION**

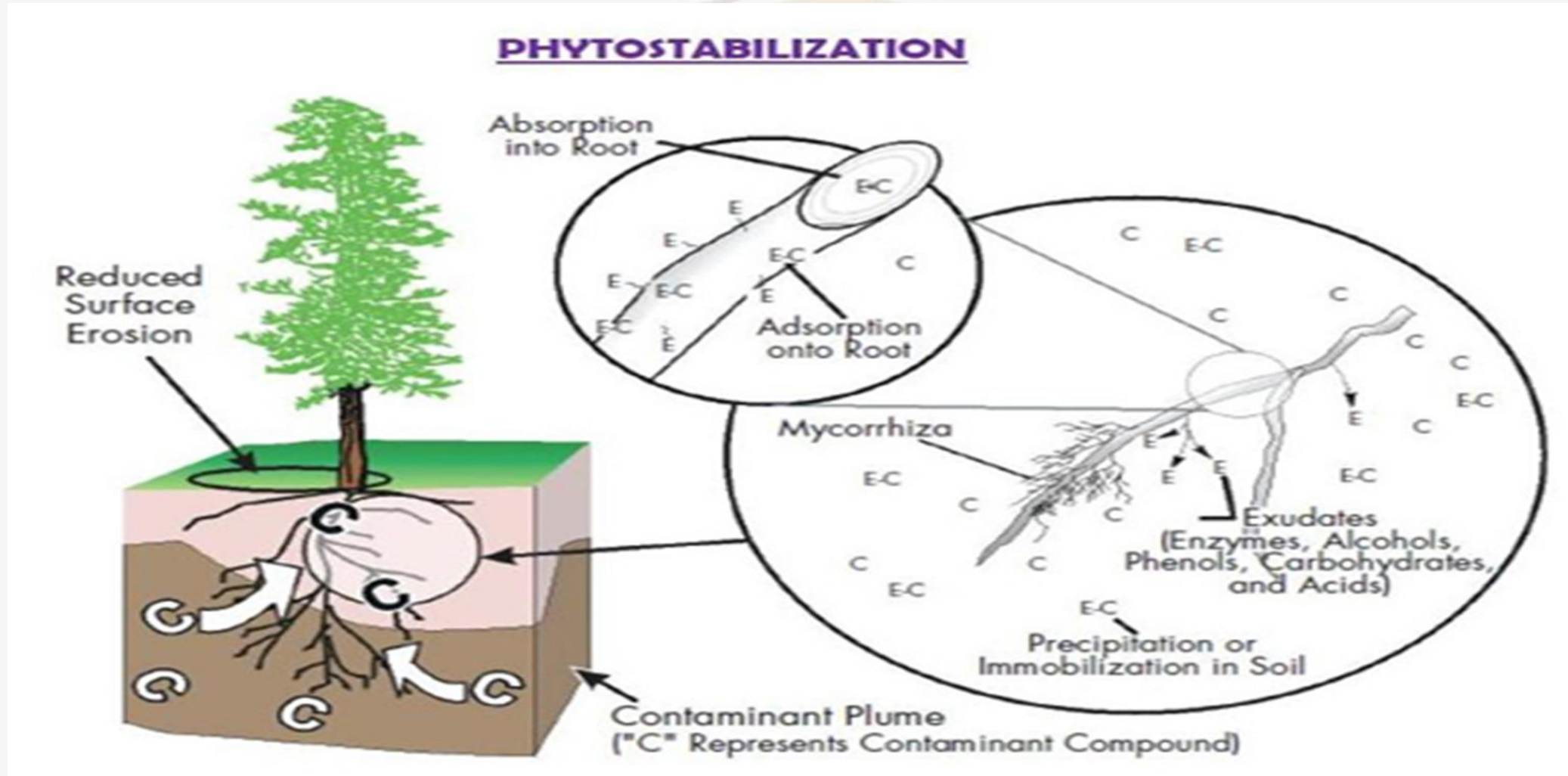
- This is also referred to as in place inactivation.
- Phytostabilisation is the use of certain plant species to immobilize contaminants in the soil and groundwater through absorption and accumulation by roots, adsorption onto roots, or precipitation within the root zone of plants (rhizosphere)
- It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

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- 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.
- Example: Phytostabilization using metal-tolerant grasses is being investigated for large areas of Cd- and Zn- contaminated soils at a Superfund site in Palmerton, United states.

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<https://knowhowtogmo.wordpress.com/2011/01/31/phytostabilization/>

## Advantages of Phytoremediation

- “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
- Minimal land disturbance.
- Reduces potential for transport of contaminants by wind, reduces soil erosion.
- Multiple contaminants can be removed with the same plant.

## Disadvantages of Phytoremediation

- Limited to the surface area and depth occupied by the
- 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 plants which then pass into the food chain, from primary level consumers upwards and/or requires the safe disposal the affected plant material.

## REFERENCES

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- Manual of Environmental Microbiology by Christon J. Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Aaron L. Mills, ASM Press, 2007.
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*Thank you*

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