RIZVI COLLEGE OF ARTS SCIENCE AND COMMERCE

PHYTOREMEDIATION

USBO503
SEMV
DR NITESH JOSHI
DEPT OF BOTANY

TECHNOLOGY

Technology that use plants to clean up contaminated sites.

- green technology that uses plants systems for remediation and restoration.
- encompasses microbial degradation in rhizosphere as well as uptake, accumulation and transformation in the plant.

Current Methods

- Current methods mainly remove and transport to RCRA land fill or pump and treat type systems.
- Many sites are large and pollution is not high but still violates standards.
- For secondary or tertiary treatment of waste water.

How does it work?

- Plants in conjunction with bacteria and fungi in the rhizosphere

- transform, transport or store harmful chemicals.

- Plants attributes make them good candidates

- root system surface area to absorb substances and efficient mechanisms to accumulate water, nutrients and minerals.
- selectively take up ions
- developed diversity and adaptivity to tolerate high levels of metals and other pollutants.

PHYTOREMEDIATION MECHANISMS

Phytoremediation mechanisms

Phytoextraction
Phytostabilization
Phytotransformation
Phytostimulation
Phytovolatilization
Rhizofiltration

Mechanisms

Phytotransformation/Phytodegradation

- pollutant is taken up by the plant and transformed in plant tissue (to be effective must be transformed to a less toxic form).
- Trichloroethylene (TCE), a prevalent ground water contaminant, transformed to less toxic metabolites by using hybrid poplar tree.
- Air Force facility in Texas using cottonwoods to treat a large ground water plume of TCE.
- EPA research lab using parrot feather (a common aquatic weed) for TNT treatment.

Phytoextraction

- Uptake of chemical by the plant.
- Works well on metals such as lead, cadmium, copper, nickel etc.
- Detroit lead contaminated site was removed with Sunflower and Indian Mustard.
  - recently researchers at the University of Florida have determined that a species of fern, native to the south east, stores high concentrations of arsenic in its fronds and stems more than 200 times the concentration in the soil.

Phytostabilization

- Vegetation holds contaminated soils in place
  - root system and low growing vegetation prevent mechanical transportation of pollutants from wind and erosion.
  - Trees transpire large quantities of water (more than 15 gal/day) so pumping action prevents contaminants from migration into the water table.

Rhizofiltration

- Use the extensive root system of plants as a filter.
- 1995, Sunflowers were used in a pond near Chernobyl
  - approx. 1 week they had hyperaccumulated several thousand times the concentration of cesium and strontium.
  - hyperaccumulation can contain 100 times or more of contaminant than normal plant.

Rhizosphere Bioremediation

- Increase soil organic carbon, bacteria, and mycorrhizal fungi, all factors that encourage degradation of organic chemical in soil.
- The number of beneficial bacteria increased in the root zone of hybrid poplar trees and enhanced the degradation of BTEX, organic chemical, in soil.

Advantages

- Cost effective when compared to other more conventional methods.
- "nature" method, more aesthetically pleasing.
- minimal land disturbance.
- reduces potential for transport of contaminants by wind, reduces soil erosion
- hyperaccumulaters of contaminants mean a much smaller volume of toxic waste.
- multiple contaminants can be removed with the same plant.

Disadvantages

- Slow rate and difficult to achieve acceptable levels of decontamination.
- Potential phase transfer of contaminant.
- Possibility of contaminated plants entering the food chain.
- Disposal of plant biomass could be a RCRA regulated hazard substances.
- Possible spread of contaminant through falling leaves.

Disadvantages (cont.)

- Decrease in action during winter months when trees are dormant.
- Trees and plants require care.
- Contaminant might kill the tree.
- Degradation product could be worse than original contaminant.
- Much testing is needed before a procedure can be utilized (EPA approval)

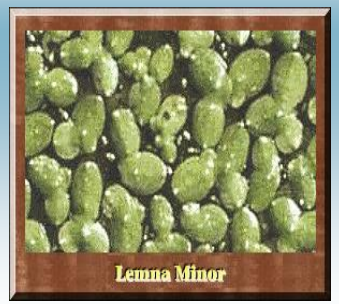
Aquatic plants for wastewater treatment

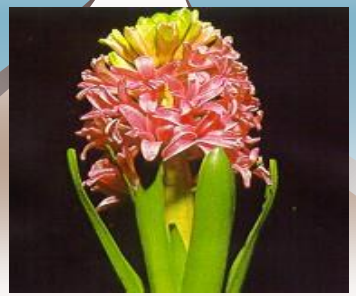
- Aquatic plants are chosen for absorb particular nutrient and to remove pathogens, metals and other contaminants from wastewater.

- Aquatic plants have been shown to be very effective as a secondary or tertiary state for water treatment and nutrient removal.

Aquatic plant for waste water treatment

- Water Lily has an extensive root system with rapid growth rates, but is sensitive to cold temp, it is an ideal plant for water treatment in warm climates.
- Duckweed (Lemma spp.) has greater cold tolerance and a good capacity for nutrient absorption.
- Penny wort (Hydrocotyl spp) is relatively cold tolerant with a very good capacity for nutrient uptake.
- Water hyacint uptake of heavy metal eg.,Pb,Cu,Cd,Hg from contaminated water.





Function of plants in aquatic treatment

Plant Parts	Functions
◆Roots and/or stem in water column	◆ Uptake of pollutants ◆ surfaces on which bacteria grow ◆ media for filtration and adsorption of solids
◆ Stem and/or leaves at or above water surface	◆ Attenuate sunlight, thus can prevent growth of suspended algae. ◆ Reduce effects of wind on water ◆ Reduce transfer of gases and heat between atmosphere and water.

Contaminant removal mechanisms

Physical	Chemical	Biological
Sedimentation	Precipitation	Bacterial metabolism
Filtration	Adsorption	Plant metabolism
Adsorption	Hydrolysis reaction	Plant absorption
Volatilization	Oxidation reaction	Natural die-off

Rhizofiltration

- **Applicability**

A suitable plant for rhizofiltration applications can remove toxic metals from solution over an extended period of time with its rapid-growth root system. Various plant species have been found to effectively remove toxic metals such as Cu^{2+}, Cd^{2+}, Cr^{6+}, Ni^{2+}, Pb^{2+}, and Zn^{2+} from aqueous solutions. Low level radioactive contaminants also can be removed from liquid streams.

Rhizofiltration (cont.)

- **Limitations**

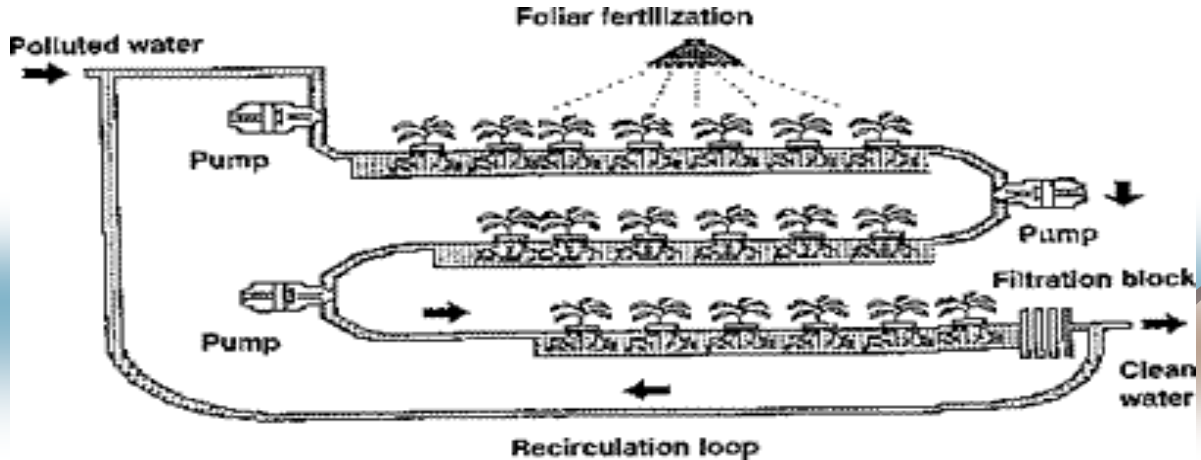
  Rhizofiltration is particularly effective in applications where low concentrations and large volumes of water are involved.

- **Data Requirements**
  - Depth of contamination,
  - Types of heavy metal present,
  - Level of contamination must be determined and monitored.
  - Vegetation should be aquatic, emergent, or submergent plants.
  - Hydraulic detention time and sorption by the plant roots must be considered for a successful design.

Rhizofiltration (cont.)

The example of an experiment

The plant root immersed in flowing contaminated water until the root is saturated. The metal concentrated in the roots was analyzed on a dry weight basis using Atomic Absorption Spectrophotometry(AAS). The amount to metal taken up by the roots from various solutions was compared on the basis of recovery rate (µg metal in roots/µg metal in solution) and bioaccumulation coefficient (ppm metal in roots / ppm of metal in solution).



Rhizofiltration (cont.)

- Other factors that should be considered

- Potential of failure modes and contigencies

  Rhizofiltration may not succeed for a number of reasons, including mortality of plants for reasons such as management, weather extremes, soil conditions or pest.

- Field studies

  Field studies are required before full-scale application. Specific information include rates of remediation, irrigation requirements, rates of soil amendments, and plant selection. Formulating clear objectives, appropriate treatments, experimental units and planning are important considerations in field studies.

- Economic

  This technique should be less cost than traditional technologies such as excavation, thermal desorption, landfilling etc.

Conclusion

- Although much remains to be studied, phytoremediation will clearly play some role in the stabilization and remediation of many contaminated sites. The main factor driving the implementation of phytoremediation projects are low costs with significant improvements in site aesthetics and the potential for ecosystem restoration.