Phytoremediation

A Community Fact Sheet

Phytoremediation
Phytoremediation is the use of certain plants to clean up soil, sediment, and water contaminated with metals and/or organic contaminants such as crude oil, solvents, and polyaromatic hydrocarbons (PAHs). It is a name for the expansion of an old process that occurs naturally in ecosystems as both inorganic and organic constituents cycle through plants. Plant physiology, agronomy, microbiology, hydrogeology, and engineering are combined to select the proper plant and conditions for a specific site. Phytoremediation is an aesthetically pleasing mechanism that can reduce remedial costs, restore habitat, and clean up contamination in place rather than entombing it in place or transporting the problem to another site.

Phytoremediation can be used to clean up contamination in several ways:

- **Phytovolatilization:** Plants take up water and organic contaminants through the roots, transport them to the leaves, and release the contaminants as a reduced of detoxified vapor into the atmosphere.
- **Microorganism stimulation:** Plants excrete and provide enzymes and organic substances from their roots that stimulate growth of microorganisms such as fungi and bacteria. The microorganisms in the root zone then metabolize the organic contaminants.
- **Phytostabilization:** Plants prevent contaminants from migrating by reducing runoff, surface erosion, and ground-water flow rates. "Hydraulic pumping" can occur when tree roots reach ground water, take up large amounts of water, control the hydraulic gradient, and prevent lateral migration of contaminants within a ground water zone.
- **Phytoaccumulation/extraction**: Plant roots can remove metals from contaminated sites and transport them to leaves and stems for harvesting and disposal or metal recovery through smelting processes.
- **Phytodegradation by plants:** Organic contaminants are absorbed inside the plant and metabolized (broken down) to non-toxic molecules by natural chemical processes within the plant.

The following list gives the media, contaminants and typical plants for the types of phytoremediation listed above.

Application	Media	Contaminants	Typical Plants
1. Phytovolatization	Soil, groundwater, Landfill leachate, land application of wastewater	Herbicides (atrazine, alachlor); Aromatics (BTEX); Chlorinated aliphatics(TCE); Nutrients; Ammunition wastes(TNT,RDX)	Phreatophyte trees(poplar,willow, cottonwood,aspen); Grasses(rye, Bermuda, sorghum, fescue); Legumes (clover, alfalfa, cowpeas)
2. Microorganism stimulation	Soil, sediments, Land application of waste water	Organic contaminants(pesticides aromatic, and polynuclear aromatic hydrocarbons	Phenolics releasers(mulberry, apple,osage orange); Grasses with fribous roots(rye,fescue,bermuda); Aquatic plants for sediments
3.Phytostabilization	Soil, sediments	Metals (Pb,Cd,Zn,As,Cu,Cr,Se,U), Hydrophobic Organics (PAH,PCB,DDT,dieldrin)	Phreatophyte trees to transpire large amounts of water(hydraulic control); Grasses to stabilize soil erosion; Dense root systems are needed to sorb/bind contaminants
4. Phytoaccumulation/extraction	Soil, Brownfields, sediments	Metals(Pb,Cd,Zn,As,Cu,Cr,Se,U) with EDTA addition for Pb Selenium	Sunflowers; Indian Mustard; Rape seed plants; Barle, Hops; Crucifers; Serpentine plants; Nettles, dandelions
5. Degradation	Soil, groundwater, Landfill leachate, land application of wastewater	Herbicides (atrazine, alachlor); Aromatics (BTEX); Chlorinated aliphatics(TCE); Nutrients; Ammunition wastes(TNT,RDX)	Phreatophyte trees(poplar,willow, cottonwood,aspen); Grasses(rye, Bermuda, sorghum, fescue); Legumes (clover, alfalfa, cowpeas)

Advantages and Disadvantages of Phytoremediation

When using phytoremediation there are many positive and negative aspects to consider. Some possible advantages and disadvantages are listed below.

Advantages	Disadvantages
Works on a variety on organic and inorganic compounds	May take several years to remediate
Can be either In Situ/ Ex Situ	May depend on climatic conditions
Easy to implement and maintain	Restricted to sites with shallow contamination within rooting zone
Low-cost compared to other treatment methods	Harvested biomass from phytoextraction may be classified as a RCRA hazardous waste
Environmentally Friendly and aesthetically pleasing to the public	Consumption of contaminated plant tissue is also a concern.
Reduces the amount wastes to be landfilled	Possible effect on the food chain

A major advantage that is listed above is the low cost. For example, the cost of cleaning up one acre of sandy loam soil at a depth of 50cm with plants is estimated at $60,000-$100,000 compared to $400,000 for the conventional excavation and disposal method. One reason for this low cost is phytoremediation may not require expensive equipment or highly specialized personnel, and can be relatively easy to implement.

One major concern with phytoremediation is the possible affects on the food chain. For example vegetation is used that absorbs toxic or heavy metals and moles or voles eat the metal contaminated plants. The predators of the moles or voles then become victims of intoxication. All though the possibilities of such scenarios are being looked at, more fieldwork and analysis is necessary to understand the possible effects phytoremediation can have.

Regulatory issues

As of now phytoremediation is too new to be approved by regulatory agencies such as the EPA. Eventually the main question that regulators will focus on is will phytoremediation remediate the site to the standards and reduce the risk to human health and the environment. In developing regulations for phytoremediation the following questions will need answering.

- Can it cleanup the site below action levels? On what scale?
- Does it create any toxic intermediate or products?
- Is it cost effective as an alternative method?
- Does the public accept the technology?

Contacts

EPA citizens guide to phytoremediation

http://clu-in.org/PRODUCTS/CITGUIDE/Phyto.htm

HSRC's phytoremediation page
http://www.engg.ksu.edu/HSRC/phytorem/

Edenspace
www.edenspace.com

Phytokinetics
www.phytokinetics.com

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The Technical Assistance for Brownfields (TAB) Program provides independent technical expertise to communities with contaminated sites and promotes community involvement in site-cleanup projects. For more information about TAB, please contact Lisa Szymecko, TAB Coordinator, at **(800) 490-3890.**