Soil, Sediment, Bedrock and Sludge

Phytoremediation

Introduction:

Phytoremediation is a process that exploits plants to transfer, stabilise, and remove organic or inorganic contaminants present in soil and sediment.

Description:

The means of phytoremediation consist of enhanced rhizosphere biodegradation, phyto-extraction (phytoaccumulation), phytodegradation, and phytostabilisation.

Enhanced Rhizosphere Biodegradation:

Enhanced rhizosphere biodegradation takes place in the soil directly adjacent to plant roots. Natural substances released by plant roots provide nutrients to microorganisms, which improves their biological performance. Plant roots in addition loosen the soil and then die, leaving paths for the transportation of water and air. The process pulls water to the surface zone and dries the lower saturated zones.

The most frequently used flora in phytoremediation is poplar trees, principally because the trees are fast growing and can live in a variety of climates. Additionally, poplar trees can draw large quantities of water compared to other plant species, as it passes through soil or directly from an aquifer. This can draw greater amounts of pollutants from the contaminated media and lower the quantity of water that may pass through soil or an aquifer, thus reducing the amount of contaminant flushed though or out of the soil or aquifer.

Phyto-accumulation:

Phyto-accumulation involves the uptake of contaminants via plant roots and the translocation (phytoextraction) of contaminants to the shoots and/or leaves.

Phyto-degradation:

Phyto-degradation is the metabolism of contaminants in plant tissues. Plants generate enzymes, for instance dehalogenase and oxygenase, that assist catalyse degradation.

Phyto-stabilisation:

Phyto-stabilisation is the production of chemical compounds by a plant to immobilise contaminants at the interface between the roots and the soil.

Applicability:

Phytoremediation can be used for remediation metals, pesticides, solvents, explosives, crude oil, PAHs, and landfill leachates. Some plant species are able to store metals in their roots. As roots become saturated with metal contaminants, they can be harvested and disposed of. Hyper-accumulator plants may remove and store metallic contaminants. At present, trees are under investigation to establish their capability of removing organic contaminants from ground water and perhaps metabolise them either to CO_2 or plant tissue.

Limitations:

- Plants used decide the depth of the treatment zone. Generally, it is restricted to shallow soils.

- High concentrations of hazardous materials can be toxic to plants.
- Can be seasonal, depending on location.
- It can transfer contamination across media, e.g. from soil to air.
- The toxicity and bioavailability of biodegradation products is not always known.
- Products may be mobilised into ground water or bioaccumulate in animals.

Data Needs:

The kinds of soil used for phytoremediation projects is vital. Water movement, oxygen concentrations, root growth, and root structure all impact the growth of plants and must be carefully considered when implementing phytoremediation.

Performance Data:

A "mature tree" study has been concluded at Cape Canaveral Air Station. Live Oak, Saw-tooth Palmetto and Scrub Oak species in the midst of a TCE plume were assessed for TCE transpiration and transformation rates. Evapotranspiration rates were also measured. Mature trees were used in this study to prevent the waiting period growth into mature trees.

A preliminary planting of 110 trees in 1998 was followed by 200 (early 2000) and 150 (spring 2000) further trees at Travis AFB, CA. The plantings are being used as hydraulic control for a TCE plume. This is a long-term test of the ability of trees to control the movement of groundwater.

Cost:

The area of contamination is a major cost driver, as is the density of sampling, which could be driven by regulatory desires. Tree size (maturity) can also have an impact.