Phytoremediation

AECOM's experienced Phytoremediation team have studied the discipline known as Omics to deploy phytoremediation techniques that use greener solutions to clean up contaminated sites.

Areas of Expertise

- Site Screening
- Forensic Phytoremediation Evaluation
- Plant Selection
- Plant Uptake Studies and Potted Plant Growth Studies
- Emerging Contaminant Uptake and Transformation
- Conceptual Approach and Design
- Field Monitoring Services
- Full-Scale Implementation

Overview

Phytoremediation is the applied use of plants to transform, degrade or remove contaminants from environmental media, and is a nature-based remedial solution. The use of phytoremediation systems for the treatment of contaminants in groundwater, process wastewaters, surface water, and soil has become increasingly popular as a result of their effectiveness, relatively low capital and Operation & Maintenance costs, and increased regulatory acceptance. AECOM has been at the forefront of using cost-effective phytoremediation technologies in the United States and several other countries. Phytoremediation has been proven as a long-term, cost-effective remedial technique for controlling offsite migration of groundwater through phyto-hydraulics, and aerobically-degrading amenable contaminants such as petroleum, Benzene, Toluene, Ethylbeneze and Xylene (BTEX) and Polycyclic Aromatic Hydrocarbons compounds. In addition, phyto-technologies can also be applied to other wastestream treatments including metals (phytoextraction and phytosequestration), energetic compounds, and emerging compounds such as 1,4-dioxane. Per and Polyfluoroalkyl Substances (PFAS) can also be extracted into foliar tissues of plants through phytoextraction mechanisms.

Phytoremediation systems are gaining acceptance by the regulatory community and include the added benefits of providing site stabilization, visual screening, and habitat restoration. Such systems are unobtrusive, typically do not interfere with other remediation systems, and can be a supplement or cornerstone of a site's long-term remedial closure and site restoration plan. Whether the application be remediation of contamination in soil and groundwater, hydraulic control for reduction of off-site groundwater migration, or the polishing of a wastewater stream prior to reintroduction to the environment, AECOM strives to design effective and cost-efficient systems using proven, phytoremediation technologies.

GROUNDWATER PHYTOREMEDIATION DECISION TREE

Determining Cost-Effective Applications

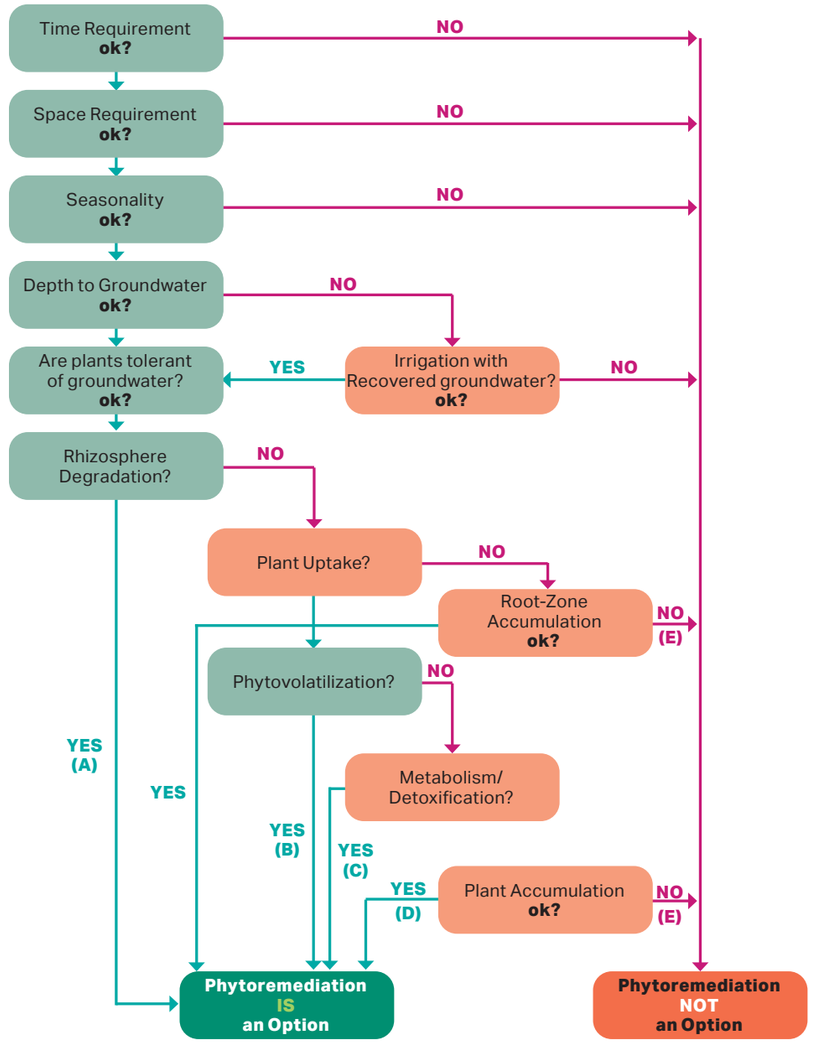
Plants take 1-3 years to become established.

Depends on the required thickness of capture-zone and the permeability of the aquifer.

Tree water-use declines in winter. Plumes can be controlled year round by adjusting shape and size of the tree stand.

Special cultural practices can train tree roots down to 25-ft. For deeper water tables, consider irrigating trees with recovered groundwater.

Level of tolerance depends on contaminant types, concentrations, and plant species. Greenhouse studies may be necessary to assess an appropriate plant type.



LEGEND

(A) BTEX
BTEX compounds are degraded by microbes residing in the plant root-zone (rhizosphere).

(B) TCE/Dioxane
TCE and 1,4-dioxane can be taken up, translocated and exit plant shoots (phytovolatilization). This may be followed by UV-degradation in the atmosphere.

(C) TNT/TCE
TNT and TCE; following plant uptake, these compounds are metabolized and detoxified by plant enzymes.

(D) Cd
Cd and other metals can safely accumulate in the woody tissue of trees.

(E) Chlordane/RDX
Depending on conditions, for sites contaminated with chlordane.

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Phytoremediation *(continued)*

Natural Remediation using Salt-tolerant Trees

Natural Remediation using Indigenous Grasses

Our Approach

PHYTOREMEDIATION TECHNOLOGIES AND NBS. Nature-based Solutions (NbS) has garnered much interest and are a focus of recent Biden-administration initiatives to improve climate progress and resiliency, facilitate natural improvements, and improve upon human equity and prosperity. These concepts are included in the White House Council on Environmental Quality's documents **Opportunities to Accelerate Nature-Based Solutions** and **Nature-Based Solutions Resource Guide** (November 2022). AECOM has adopted and integrated NbS into remedial approaches and designs as a way to foster improvements to natural conditions, which in turn creates better living environments for wildlife and human beings. Phytoremediation is a core NbS discipline.

AECOM uses various Molecular Biological Tools (MBTs) to evaluate the presence, behavior and performance of bacteria and archaea residing in both the soil rhizosphere, aquifer, and plant tissues. The approach is to establish environmental baselines regarding the microbial community and use a weight of evidence evaluation in assessing the performance of plant-assisted remediation in a modern omics-driven era.

ENHANCED RHIZODEGRADATION (PLANT-ASSISTED BIOREMEDIATION). Enhanced rhizodegradation, or plant-assisted bioremediation is an enhanced biodegradation method for treating organic chemical pollutants by root-dwelling bacteria and fungi living under the influence of select plant species. This biodegradation method is facilitated by a "rhizosphere effect" where plant roots improve soil quality through bioturbation and increased aeration, increased porosity, deposit carbon-containing compounds (rhizodeposition) into the soil, and produce other compounds beneficial to microbial growth. Specific root compounds may be released that have the ability to support and stimulate the growth and metabolic activities of bacteria, including those that can degrade recalcitrant organic compounds. Other root secretions such as root lysates (e.g. phenolic compound) have the capacity to stimulate genes that produce enzymes responsible for microbial metabolism of persistent organic pollutants. Plants may also release surfactants from roots that can reduce interfacial surface tensions of pollutants and increase their aqueous solubility.

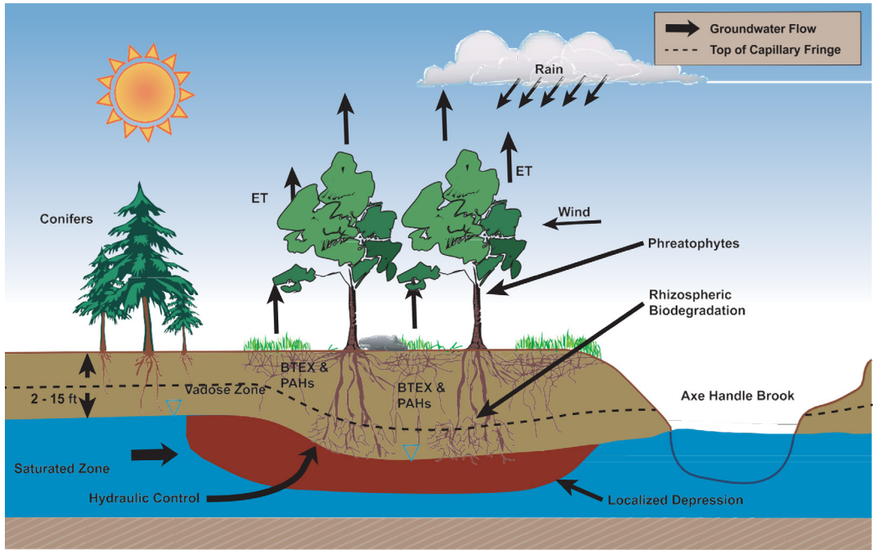
CONTROLLING GROUNDWATER CONTAMINANT PLUMES. The use of stands of deep-rooted trees to control migration of groundwater contaminant plumes is an innovative approach that is becoming increasingly popular. These systems are cost effective with very low operation and maintenance costs.

Special practices have been developed to train roots to extend through a relatively thick vadose zone so that trees can use groundwater from the capillary fringe. The deep-rooted tree stands create a capture zone—a specific thickness of the saturated zone where the groundwater passing beneath the root-zone is used by the trees. Dissolved contaminants that enter the capture zone can be removed by phytoremediation processes (e.g. microbial degradation in the plant rhizosphere, sorption to roots, plant uptake and detoxification, phytovolatilization, etc.). This approach is useful for many compounds including chlorinated solvents, petroleum hydrocarbons, 1, 4-dioxane, and MTBE. Staggered multiple rows of trees are planted perpendicular to the direction of groundwater flow at the leading edge of the contaminant plume. The rate of maximal groundwater removal occurs at stand maturity (canopy closure). Plant transpiration results in a significant vertical hydraulic influence, creating an upward driving force to capture groundwater passing through the aquifer. Thicker capture zones are created by increasing the number of rows of trees. This effect is most pronounced for aquifers with lower hydraulic conductivity.

PHYTOREMEDIATION OF PFAS. AECOM is at the forefront of PFAS uptake and transformation work. In May 2017, AECOM developed an unpublished white paper Plant-Assisted Remediation of PFAS which identified various pathways and mechanisms for PFAS uptake and transformation. Later, AECOM provided additional insight into phytoremediation of PFAS through international conference proceedings in 2017, 2018, 2021, 2022 and 2023 (forthcoming). Ongoing research includes mining for novel rhizospheric bacteria in PFAS plumes and role of other natural soil and plant tissue factors in sequestering and altering PFAS.

Key AECOM Attributes

- Phytoremediation falls under the NbS umbrella and helps improve native habitat, increase biodiversity and improve upon the human condition.
- In the United States, AECOM has focused NbS teams in Oakland, California, Grand Rapids, Michigan and Chelmsford, Massachusetts with team support globally distributed.
- AECOM phytoremediation services extend from site screening and site suitability, bench-scale, pilot-scale and full-scale applications.



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