

Phytoremediation removes Volatile Organic Compounds at Argonne National Laboratory

Using trees to restore groundwater resources –
turning an environmental liability into a research opportunity

Historic context

In the late 1950s, waste from research activities at Argonne was disposed of in Area 317/319. Since then, volatile organic compounds (VOCs) like trichloroethene (TCE) and tetrachloroethene (PCE) from the waste have been released into the soil and groundwater. Most of the contamination has now been removed but low levels are still found in soil and groundwater to depths of about 6-9 m (20-30 feet). Argonne has taken steps to minimize any further release of contaminants to the groundwater and to achieve hydraulic control of the contaminated plume. Phytoremediation, or the use of green plants to remove contaminants from the environment, has been selected to complete the cleanup and in time replace mechanical extraction.

Treemediation®, a phytoengineering technology owned by Applied Natural Sciences, Inc, was implemented at Argonne in 1999 to enable roots of phreatophytes (moisture seeking plants such as poplars and willows) to extend their root systems down to 9 m depth (30 feet) to extract contaminated groundwater, while avoiding clean, perched aquifers present in the area. It does so by providing the necessary conditions for the roots to search for water at depth independent of surface moisture. Innovative hydrogeological modeling aided the design and planning phase of the remedial planting.

Why this technology?

Because of the complexity of the glacial terrain at the site, extraction wells (the conventional approach) would have unpredictable performance and would generate waste groundwater. Conversely, roots seek water at the capillary

fringe, and are thus a more dynamic and flexible technical choice. No waste is generated by the trees.

Additionally, a tree system is the ultimate solar-powered extraction technology, is cost-competitive with other alternatives, and is synergistic with ecological restoration.



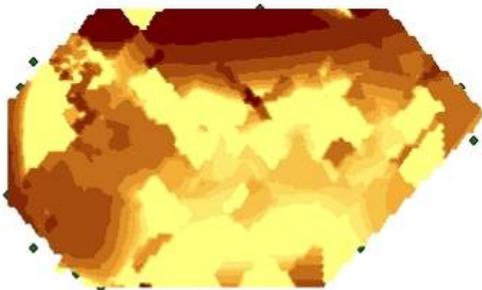
The 4-acre phytoremediation site at Argonne was planted in 1999 with approximately 900 poplar and willow trees.

Results

The project is now in long-term monitoring phase
As part of this project, new methods for trace analysis of contaminants are being developed, new monitoring methods are being tested, and new information on fate and transport of contaminants is being developed.

On average, each poplar tree planted at the site has been shown in actual field measurements to transpire approximately 100 L/day (26 gal/day) of the contaminated groundwater, consistent with the original model assumptions. With the groundwater, the trees are removing VOCs. VOCs and their degradation products are found in plant tissue, indicating that they are being removed from the subsoil and partly degraded in the plant.

Determining performance is the most important unresolved issue in broadening the implementation of innovative technologies such as phytoremediation: Argonne has been using this field site to develop base knowledge such as partitioning, desorption, and uptake of VOCs in soil-plant systems and develop an analytical model of the relationship between soil/water concentrations and tree concentrations. This model is finding practical application in determining quantitative VOC removal rates by trees using field data. This information will in turn help us determine the progress of the remedial action. It is also helping us find faster and cheaper ways to monitor contaminated sites.



Tree branch analysis is used to generate “biomaps” of the contaminated plume using geostatistical methods.

Other Phytotechnologies capabilities at Argonne

- ✓ Phyto-Bioremediation of **oil hydrocarbons** in temperate and arctic regions
- ✓ Phytoremediation of **carbon tetrachloride** combined with wetland technologies
- ✓ Phytoremediation of **salt brines** (produced waters) from natural gas extraction
- ✓ Phytoremediation of **radionuclides**.



Plant tissue samples are analyzed by gas chromatography to determine VOC uptake.

Selected Literature

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Gopalakrishnan G., M.C. Negri, B.S. Minsker and C. J. Werth (2007). Monitoring subsurface contamination using tree branches. *Groundwater Monitoring and Remediation* 27 (1), 65:74.

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Argonne National Laboratory is certified to ISO 9001 and ISO 14001 international standards.

This multidisciplinary effort is conducted by a team of Argonne scientists and engineers from several Divisions: Energy Systems, Environmental Science, and Environmental Safety and Quality. Core expertise includes agronomy, environmental engineering, ecology, analytical chemistry, hydrogeology and modeling.