United States Environmental Protection Agency | Solid Waste and Emergency Response 5403W | EPA 510-F-93-022 October 1993

EPA

Soil Remediation For UST Sites

In Situ Bioremediation: Bioventing

In situ bioremediation—bioventing*—is a technique for removing biodegradable contaminants from unsaturated soils. The technique injects oxygen into contaminated soil. The oxygen stimulates the aerobic biodegradation of the organic contaminants in the soil. Oxygen is delivered at a low rate to encourage biodegradation rather than volatilization.*

Bioventing is most effective in coarse-grained soils such as sand and gravel. It requires a minimum 5-foot-thick unsaturated zone. This technique can be used in conjunction with air sparging or groundwater pumping systems.

This technique is able to treat large volumes of soil effectively and with minimal disruption to business operations. It also can remove contamination from near or under fixed structures. Bioventing also reduces the need for aboveground treatment because it works to degrade contaminants in place.

Petroleum Types And Constituents

- Fresh or weathered gasoline, diesel, jet fuel, kerosene, motor oil, heavy fuel oil, lubricating oils, and crude oils
- Volatile organic compounds (VOCs) such as benzene, toluene, ethylbenzene, and xylene (BTEX); residual semivolatile organic compounds (SVOCs) such as polynuclear aromatic hydrocarbons; and nonvolatile constituents

In Situ Bioremediation: Bioventing

Advantages	• Degrades semivolatile organic compounds (SVOCs) and nonvolatile organic compounds • Effectively treats large volumes (>1,000 cu yd) of soil • Causes minimal disruption to business operations • Degrades contaminants near or under fixed structures • Degrades volatile organic compounds (VOCs) in place, which reduces air emissions and subsequent need for treatment
Limitations	• Targets only biodegradable constituents • Is a relatively slow process • Requires sufficient nutrients, moisture, active indigenous microbial population, and pH of 6-9 to degrade contaminants • Effectiveness limited in heterogeneous soils
System Components	• Vertical or horizontal extraction wells • Trenches • Vacuum blower or pump • Injection and passive inlet wells • Vapor treatment (optional) • Nutrient delivery equipment (optional)

Wastestream Treatment	• Vapor treatment options (might be needed for high concentrations of contaminants):
	  • *Vapor phase biofilter*
	  • *Granulated activated carbon*
	  • *Internal combustion engine*
	  • *Catalytic oxidation unit*
	  • *Thermal incinerator*

Parameters to Monitor[1]	• Vapor concentration • Airflow rate • In situ respiration rate (oxygen consumption and carbon dioxide production) • Soil contaminant concentration • Microbial population • Soil pH, moisture, and nutrients
Cleanup Levels and Timing[2]	• Treats ≥ 90% of biodegradable constituents • For an ideal site[3], ~90% in 1 to 2 years • For an average site[4], ~90% in 1 to 4 years • Longer time required to degrade heavier hydrocarbons
Costs[5]	• For an ideal site[3], $40,000 to $120,000 • For an average site[4], $100,000 to $150,000 • Vapor treatment and longer treatment times increase costs

[1]"Parameters to monitor" are for performance purposes only; compliance monitoring parameters vary by state.
[2]Cleanup standards are determined by the state.
[3]An "ideal site" assumes no delays in corrective action and a relatively homogenous, permeable subsurface.
[4]An "average site" assumes minimal delays in corrective action and a moderately heterogeneous and permeable subsurface.
[5]Costs include equipment, and operation and maintenance.