Perchlorate Treatment Technology
Fact Sheet
Soil Biotreatment

ClO_4^-

What Is Soil Biotreatment Technology?

Soil biotreatment technology uses bacteria to degrade soil contaminants. Treatment alternatives, can be either *ex situ* (*i.e.*, above ground) or *in situ* (*i.e.*, in place, in ground), and include biotreatment cells, soil piles, and prepared treatment beds. Soil biotreatment is typically based on the principles of soil composting (controlled decomposition of matter by bacteria and fungi into a humus-like product). In *ex-situ* processes, contaminated soils are excavated, mixed with additional soil and/or bacteria to enhance the rate of contaminant degradation, and placed in aboveground enclosures or treatment cells. *In-situ* processes use a carbon source such as chicken, horse, or cow manure. *In-situ* technologies can be active or passive depending upon whether the carbon source is applied directly to the undisturbed soil surface (*i.e.*, passive) or physically mixed into the soil surface layer (*i.e.*, active). The effectiveness of both alternatives is dependent upon careful monitoring and control of environmental factors such as moisture, temperature, oxygen, and pH, and the availability of a food source for the bacteria to consume.

Ex Situ Perchlorate Soil Biotreatment

Where has Biotreatment Been Used to Treat Perchlorate-contaminated Soils?

The DOD is conducting field studies using *in-situ* and *ex-situ* soil biotreatment technologies to treat soils at the Naval Weapons Industrial Reserve Plant (NWIRP) facility in McGregor, Texas, and at the Longhorn Army Ammunition Plant (LHAAP) in Karnack, Texas. Private industry is also demonstrating *in-situ* soil biotreatment technologies in field tests at a site in California.

Perchlorate-Contaminated Soil Biotreatment, NWIRP McGregor

NWIRP McGregor soils are contaminated with perchlorate from past industrial practices associated with manufacturing solid-fuel rocket motor propulsion systems. These contaminated soils were an ongoing contributing source for groundwater contamination with perchlorate and thus needed to be addressed as part of overall cleanup activities at McGregor. As part of its aggressive perchlorate initiative, the US Navy generated a conceptual design and implemented a soil biotreatment study at McGregor. The study allowed evaluating the overall experimental approach and produced data on the optimized mixture of nutrients and carbon sources to use as well as information on the microbe populations present. Study findings indicated that perchlorate concentrations were reduced to below the US EPA-approved reporting limit in less than a year.

Following the successful study results, perchlorate-contaminated site soil was transported to an onsite, plastic-lined engineered treatment cell. Prior to placement in the cell, the soil was mixed with a carbon source, nitrogen and phosphorous fertilizer (micronutrients), soda ash (buffer), and water in quantities/ratios determined during the preliminary study. Additional water was added and the cell was covered with a plastic liner. After 6 months, soil was sampled at 6 random locations and analyzed for perchlorate. All six samples were below the target cleanup level.

Site Facts

Locations: NWIRP McGregor, Texas and Longhorn Army Ammunition Plant, Texas

Site Descriptions: Former solid rocket motor manufacturing facilities

Contaminated Media: Soil

Treatment Technology: Anaerobic landfarming

Objective: Clean up perchlorate from soils

Status: Field demonstrations

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Perchlorate-Contaminated Soil Biotreatment, Longhorn Army Ammunition Plant (LHAAP)

Laboratory and field studies, supported by US Army Operations Support Command, were conducted at LHAAP to demonstrate the feasibility of *in-situ* bioremediation of perchlorate-contaminated soils. Laboratory tests identified chicken manure, cow manure, and ethanol as suitable carbon sources for the enhancement of *in-situ* bioremediation of perchlorate. After ten months, complete removal of perchlorate was observed within 1-2 feet, with varied levels of reduction in the deeper layers. At the termination of the field study, the concentration of perchlorate in the wettest cells had decreased to non-detectable levels. The results demonstrate that perchlorate-contaminated soils can be treated *in situ* by delivering nutrients and carbon sources to desired depths.

In situ bioremediation of perchlorate-contaminated soils at LHAAP

Industry Initiatives

The private sector is also investigating different methods of soil biotreatment. One of the methods is a passive, *in-situ* approach that consists of applying water-saturated cow manure to the soil surface, and allowing bacteria, moisture, and organic material from the manure layer to leach into the soil, aided by rainfall in the winter. Perchlorate-reducing bacteria present in manure and soil are then provided with the proper conditions of food, moisture, and reduced oxygen without any soil disturbance. During the first 30 days of the industry study, following initial placement of wet cow manure, biodegradation destroyed over 90% of perchlorate in the high-perchlorate areas. Other industry research has shown that alternative electron donors, such as molasses and calcium magnesium acetate, are effective at *in-situ* biodegradation of perchlorate in soils.

Cost Effectiveness

Because soil biotreatment technology is relatively new, there are not many comparable examples from which to obtain cost, performance, and long-term operation and maintenance data. However, on-site biotreatment of perchlorate-contaminated soil at NWIRP McGregor reportedly lowered remediation costs by approximately $100,000 relative to conventional excavation and offsite transportation and disposal. Data from conventional soil biotreatment technologies suggest that *ex-situ* alternatives requiring the excavation of contaminated soils will be more costly than either active or passive *in-situ* alternatives. For instance, *in-situ* biotreatment techniques applied to other contaminated soils have been estimated to cost between $25 to $50 per cubic yard; while *ex-situ* techniques (involving bed preparation and placement of soil in a prepared liner) have been estimated to cost up to $75 per cubic yard.

Advantages

- Short-term technology that can be used to treat localized hot spots
- Can be used to treat source contribution zones
- Treatment costs may be less than conventional dig-haul-treat approaches
- Passive treatment is relatively simple and inexpensive because there is no required soil mixing

Disadvantages

- *Ex-situ* treatment of contaminated soils may require significant excavation and manipulation
- Current research suggests that biological processes are most effective when the contaminant is within 18 inches of the surface
- Static, non-mechanical treatment process may result in less uniform treatment than processes that involve periodic mixing
- Potential for contamination downstream (*e.g.*, *Escherichia coli* from manure or nitrates from nutrients)
- Site specific climatic and hydrogeochemical conditions impact effectiveness.