gPRO® Technology

Perchlorate Treatment Technology Fact Sheet in situ Anaerobic Bioremediation

What is In Situ Anaerobic Bioremediation?

In situ (i.e., in place) bioremediation is an innovative remedial technology that eliminates the need for aboveground treatment by using biological processes to destroy or transform contaminants in groundwater or soil while they are underground. Anaerobic bioremediation requires an absence of oxygen. Studies have shown that perchlorate can be successfully biodegraded to the chloride ion but only anaerobically. The in situ anaerobic bioremediation of perchlorate is a promising technology in which naturally occurring microorganisms are used to biodegrade or consume perchlorate as a food source. For in situ bioremediation to occur, an electron donor (i.e., carbon source) such as acetate, lactate, or molasses is added to perchlorate-contaminated groundwater or soil. The carbon source stimulates the microorganisms to degrade the contaminant in situ. However, in situ bioremediation requires careful consideration of environmental conditions, hydraulic flow, and residence time of the contaminated water in the underground reactive zone. Because perchlorate reduction has been shown to occur anaerobically, initial research into the use of in situ bioremediation as a means of treating perchlorate contaminated groundwater has focused on developing and optimizing anaerobic bioremediation.

What Studies Have Investigated In Situ Bioremediation of Perchlorate?

The Strategic Environmental Research and Development Program (SERDP) is the DOD's corporate environmental R&D program, planned and executed in full partnership with the DOE and the US EPA. SERDP focuses on cleanup, compliance, conservation, pollution prevention, and Unexploded Ordnance (UXO) technologies. In recent years, SERDP has directed significant efforts towards developing cost-effective in situ bioremediation technologies for perchlorate. This included funding three projects to investigate the use of in situ anaerobic bioremediation for treating perchlorate-impacted groundwater. Under SERDP, Southern Illinois University is developing a library of microorganisms capable of degrading perchlorate. The effort is also investigate the following questions:

- Are perchlorate-reducing bacteria widespread in the environment?
- Do all perchlorate-reducing bacteria have a chlorite dismutase enzyme?
- Can indigenous microbial perchlorate reduction be stimulated in contaminated environments?
- Can the stimulated perchlorate-reducing bacteria population remove perchlorate concentrations to low levels?
- Will the rate of microbial perchlorate reduction be affected by environmental conditions?
- Will the stimulated perchlorate-reducing population also enhance the biodegradation of co-contaminating organics?

Two private sector companies are also conducting SERDP-funded research and testing of in situ anaerobic bioremediation of perchlorate. Results indicate that the technology has great promise for use in treating perchlorate-contaminated groundwater. These studies have identified the critical factors that influence the effectiveness of the technology. For example, more than 30 different strains of perchlorate-reducing bacteria have been isolated from diverse environments. These bacteria appear to be widespread. The perchlorate can typically be degraded to chloride and water by the microorganisms in less than 30 days in laboratory experiments. The presence of oxygen, nitrate, and low pH are inhibitory of perchlorate reduction by these bacteria; and most perchlorate respiring microorganisms are capable of living under varying environmental conditions. DOD's Environmental Security Technology Certification Program (ESTCP) is also funding three projects to evaluate perchlorate treatment technologies. The goal of ESTCP is to demonstrate and validate promising, innovative technologies that target DOD's most urgent environmental needs. The three ESTC projects evaluating in situ anaerobic bioremediation of perchlorate begin in 2002. These and other current research efforts are helping to advance the technology and reduce the potential costs associated with current in situ anaerobic bioremediation of perchlorate.

Cost Effectiveness:

Because the application of in situ anaerobic bioremediation technologies to perchlorate contaminated groundwater is currently being validated, defensible cost and performance data are not yet available. Completion of the field efforts should provide valuable insight into the cost and performance of the technologies.

Advantages:

- Treats groundwater without pumping to the surface; should result in significant cost savings over pump-and-treat systems.
- Biodegrades perchlorate relatively quickly; works even at low concentrations of perchlorate.
- There is an apparent abundance of naturally occurring perchlorate-reducing microorganisms in environment.
- Carbon sources demonstrated to date are relatively inexpensive.
- May treat other soil or groundwater contaminants simultaneously with perchlorate.
- Can be used to treat soil hot spots, which would prevent subsequent contamination of groundwater.
- Requires minimal aboveground structures, which is aesthetically advantageous.
- Land above ground is usable during treatment period.

Disadvantage:

- Drilling is required to deliver carbon source; targeted groundwater must be within reasonable depth limits for cost-effectiveness.
- Less certain, non-uniform treatment results from variability in aquifer, climate, weather and soil characteristics.
- Requires careful control of site-specific environmental characteristics (e.g., oxygen content, pH) to maintain optimal treatment conditions.
- Free movement of microorganisms, electron donors, or treatment by-products in groundwater may impact downstream users of groundwater, requiring longer treatment time periods.