Geosyntec consultants

Electrokinetic-Enhanced Bioremediation (EK-BioTM) for Remediation of PCE Source Area in Clay

Skuldelev, Denmark

Left: Geosyntec directed the world's first successful field demonstration of EK-Bio™

Above: The project received a U.S. Army Corps of Engineers Green Innovation Award for Sustainability

Client: NIRAS A/S

Owner: The Capital Region of Denmark

Services Provided:

- ✓ Laboratory treatability testing
- ✓ Pilot test design and oversight
- ✓ Performance monitoring analysis
- ✓ Overall technical direction

Project Objective

The success of *in situ* bioremediation (ISB) and *in situ* chemical oxidation (ISCO) depends heavily on effective and uniform delivery of remediation reagents. In low permeability soils (clays and silts), conventional hydraulic-based amendment techniques often fail to achieve appropriate amendment distribution. Electrokinetic (EK) enhanced amendment delivery is an innovative approach that uses electromigration and electro-osmosis to uniformly migrate amendments through clays and silts, since these transport mechanisms are not substantially affected by soil permeability. EK mechanisms can be applied to distribute electron donors, electron acceptors and/or bacteria for ISB (EK-Bio™), or oxidants for ISCO (EK-ISCO™).

The near-surface geology throughout much of Denmark consists of glacial clay till, which poses a significant challenge to remediation of contaminated sites. Facing this challenge, the Capital Region of Denmark retained the team of Geosyntec, NIRAS, and the U.S. Army Engineer Research and Development Center (ERDC) to design and execute the world's first field application of EK-Bio™ to remediate a tetrachloroethene (PCE) source in clay.

Geosyntec's Scope of Services

Geosyntec first directed a bench-scale treatability test in collaboration with SiREM, ERDC and North-eastern University. The team consolidated PCE-impacted clays from the test site into EK reactors. A DC power supply maintained a current density of 0.5 A/m^2 across the reactor, which effectively transported lactate and *Dehalococcoides* bacteria (*Dhc*) through the clays, promoting PCE dechlorination to ethene in the clays.

Geosyntec subsequently led the design of an EK-Bio™ field pilot test, performed start-up operation, and directed system operation and maintenance and data analysis. The system consisted of an array of 3 cathodes and 3 anodes across a test area of approximately 1.8 metres by 3 metres, with a target treatment depth of 2.7 to 7.3 metres. The lactate transport rate across the test area was estimated to range from 3 to 5 cm/day. Microbial data (molecular testing for *Dhc* and the vinyl chloride reductase gene) indicated that the EK process was successful in distributing *Dhc* within the clays. Reductive dechlorination was promoted, as evident by increases of degradation products (cis-DCE, VC and ethene) and *Dhc* levels.

Notable Accomplishments

Geosyntec and the project team accomplished the first rigorous field application of EK-Bio™, including a bioaugmentation element, in the world. The project's success advocates EK-Bio™ as a cost-effective solution for the vexing problem of chlorinated solvents in low-permeability materials and for sites with high degrees of geologic heterogeneity. The Capital Region of Denmark has selected EK-Bio™ as the preferred full-scale remedy for this PCE source area. Implementation of the full-scale EK-Bio™ remedy by Geosyntec, NIRAS and ERDC was initiated in October 2012.