From Laboratory to Full-Scale Implementation: Electrokinetically-Enhanced Delivery of Amendments for In Situ Remediation

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Background/Objectives. The success of in situ remediation technologies, such as in situ bioremediation or chemical oxidation, depends on effective delivery of remediation reagents throughout the treatment area. Traditional amendment delivery techniques are generally based on hydraulic advection mechanisms, which have limited applicability in low-permeability (low-K) materials and/or highly heterogeneous geology. Transport of ionic amendments using electric fields is independent of hydraulic properties and fluid flow in low-K soils. To date, EK has been used to successfully migrate electron donor and dehalorespiring bacteria through low-K soils at multiple field sites, promoting successful reductive dichlorination. While results have been more variable for oxidation field applications, EK has been shown to promote persulfate migration under saturated conditions at multiple sites. This presentation will discuss the fundamentals of EK transport mechanisms, results of bench-scale technology development, and results from multiple field applications in North America.

Approach/Activities. Development of the EK technologies (EK-BIO™, EK-ISCO™, EK-TAP™) included more than a decade of bench-scale studies to confirm the transport of ionic amendments through a variety of low-K soils including clays, silts, and glacial clay tills. The transport rates of various inorganic and organic amendments achieved under different current densities, as well as fate of chemical oxidants were evaluated to provide a basis for field-scale applications. Field pilot tests were conducted to validate design and operational parameters for EK-enhanced delivery for in situ bioremediation (reductive dichlorination) and chemical oxidation using persulfate (EK-TAP™).

Results/Lessons Learned. Multiple bench-scale studies have demonstrated transport rates for electron donors (e.g., lactate, acetate, citrate) ranging from 2 to 5 cm/day in clay soils. Recent field applications have observed similar rates of electron donor migration and distribution. More importantly, field applications of EK-BIO™ have shown PCE dechlorination to ethene, and substantial increases in *Dehalococcoides* and vinyl chloride reductase. EK-ISCO™ (permanganate) and EK-TAP™ (persulfate) bench tests have shown successful migration of these oxidants in fine grained silty soils, followed by oxidation of chlorinated solvent contamination. Oxidant (persulfate) migration under field EK conditions has been recently demonstrated at several sites, although oxidant migration appears to be more variable and complex than electron donor migration under EK. Through the results of the various field applications, it appears that EK-enhanced amendment delivery holds significant promise for contaminated sites with low-K and/or heterogeneous soil materials.