Electrically Induced Redox Barriers (e-barriers) - Borden Field Experiment

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Abstract  The e-barrier concept relies on polarized electrodes to deliver and recover electrons within the subsurface, resulting in the generation of oxidizing conditions at the positive electrode (anode) and reducing conditions at the negative electrode (cathode). Laboratory studies by Sale and Gilbert indicate an electrical potential applied across these closely spaced electrodes results in transformations of common organic contaminants such as tetrachloroethene (PCE) and trichloroethene (TCE).

A prototype e-barrier was constructed and installed at Canada Forces Base Borden, Ontario during the fall of 2001, to intercept an existing contaminant plume containing both PCE and TCE. After an 11-week equilibration period a potential of 5.4 V was applied across the barrier. Step-wise increases in the applied voltage to 7.8 V and 10.8 V were implemented until the completion of the first phase of the test near the end of 2002. During this time current densities increased with applied voltage. In comparing upgradient and downgradient concentrations, evidence suggests that both PCE and TCE removal increased with applied voltage. Only minor amounts of cis-dichloroethene (cis-DCE) were observed downgradient of the barrier. Cross section profiles show a continued decrease in PCE and TCE concentration downstream of the barrier. Microcosm studies indicated that the apparent distal treatment could be a result of hydrogen-enhanced biological dechlorination. In the presence of dissolved molecular hydrogen (H₂), indigenous bacteria from the Borden aquifer will sequentially degrade PCE and TCE to cis-DCE in a short period of time. The e-barrier produces hydrogen gas at the cathode by hydrolysis, which in turn will dissolve in the groundwater and be transported downgradient as an electron donor for dechlorinating bacteria.

Phase two of the Borden experiment is currently underway. Present activities are focused on mixing the highly stratified plume upgradient of the barrier in order to improve mass flux calculations. In addition, detailed monitoring during a zero voltage period will help differentiate effects of electrolytic process from other loss mechanisms.

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