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# Investigation of electrochemistry as a remedy for tetrachloroethylene plumes

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Chlorinated ethene contamination of the subsurface is extensive and harmful. Effort has been put into remediation of the low-permeable zones, where electrokinetics in combination with more traditional remedies have shown to overcome some of the challenges experienced. With a more frequent detection of chlorinated ethenes above the regulatory levels in groundwater aquifers, attempts are now being made to adapt the promising mechanisms of electrokinetics towards remediation of high-permeable zones. Electrochemical remediation is one alternative for in-situ degradation of chlorinated ethene plumes, where i) fast electrochemical reduction of chlorinated ethenes near the electrodes can be obtained [1] and ii) reactants can be generated, which can subsequently reduce or oxidize the chlorinated ethenes [2]. Focus has been on electrochemical degradation of trichloroethylene in simplified laboratory set-ups. Hence, it is necessary to assess the potential of electrochemical remediation of tetrachloroethylene (PCE) to cover the full range of chlorinated ethenes detected at contaminated sites, and to incorporate field-site characteristics in the assessment. This study aims at filling in some of the knowledge gaps that exist on application of electrokinetics for remediation of high-permeability zones at chlorinated ethene contaminated sites.

The performance of electrochemical remediation of PCE is evaluated using a flow-through column reactor with a three-electrode configuration. The significance of electrode configuration and spacing, current intensity and catalyst concentration is assessed. In addition, the influence of a porous matrix, flow rate and orientation of the reactor is examined to simulate field conditions and field-realistic designs. The two-dimensional distribution of the electric field in a sandy geology and the influence of the current intensity on this distribution is assessed in a box set-up. The column and box set-ups are furthermore used for investigation of changes in hydrogeochemistry prompted by the electric field applied.

In the initial screening of electrochemical remediation of PCE in a flow-through reactor, 86% removal was obtained. The results showed, that a 50% increase in catalyst concentration on the cathode improved the removal with 36%-point, while a 60% increase in electrode spacing enhanced the removal with 13%-point due to extension of the redox zones. An inert porous matrix was found to enhance PCE removal with 24%-point compared to a fully water-filled reactor and the horizontal orientation accounted for another 9-16% increase in removal. The observed trends are promising when considering the installation and cost of field-implementations.

[1] Wang, J., Farrell, J. (2003). Investigating the Role of Atomic Hydrogen on Chloroethene Reactions with Iron Using Tafel Analysis and Electrochemical Impedance Spectroscopy, *Environ. Sci. Technol.* 37, 3891-3896.

[2] Yuan, S., Mao, X., Alshawabkeh, A.N. (2012). Efficient Degradation of TCE in Groundwater Using Pd and Electro-generated H<sub>2</sub> and O<sub>2</sub>: A Shift in Pathway from Hydrodechlorination to Oxidation in the Presence of Ferrous Ions, *Environ. Sci. Technol.* 46, 3398-3405.