Evaluation of Partitioning Electron Donors to Improve Chlorinated Solvent Source Zone Bioremediation

Danielle F. Sylvia, Kurt D. Pennell and Natalie L. Cápiro

Chlorinated solvents such as tetrachloroethene (PCE) and trichloroethene (TCE) are among the most widespread groundwater contaminants in the United States, and pose a substantial remediation challenge, especially when present as dense non-aqueous phase liquids (DNAPLs). DNAPLs act as persistent sources of contamination emanating concentrations well-above regulatory limits. Recent studies have demonstrated that microorganisms are capable of reductive dechlorination within close proximity to chlorinated DNAPLs, which can enhance aqueous dissolution. Electron donor addition to support microbial reductive dechlorination faces two major challenges: sustained release of electron donors at the appropriate (low) concentrations and delivery of electron donors to the intended target microbes without consumption by competitors. To address these issues, partitioning electron donors (PEDs) were investigated as a long-term source of electron donor at the contaminant-water interface. Three candidate PEDS, n-butyl acetate, 2-ethyl-1-hexanol, and isopropyl-propionate, were considered. Abiotic batch experiments were conducted with a 1:3 DNAPL:aqueous solution ratio to determine both the equilibrium partitioning coefficients (K_{nw}) and relative effective mass transfer rates (K_{eo}) in TCE and PCE. Results revealed that all three PEDs readily partition into PCE- or TCE-DNAPL, with measured K_{nw} values of greater than 96 and K_{eo} values between 0.115 and 0.174 min^{-1}. In sand columns containing residual-TCE or -PCE, the PEDs persisted in the column effluent for at least 50 pore volumes (PVs) in TCE and 40 PVs in PCE following the injection of 2 PVs of aqueous PED solution. Ongoing batch and column experiments with a PCE-to-ethene dechlorinating microbial consortium are examining the viability of PEDs to support reductive dechlorination and promote biologically-enhance DNAPL dissolution. The results of these studies suggest that PED delivery and longevity in DNAPL source zones has the potential to reduce the need for frequent electron donor injections and improve bioremediation efficiency, thereby reducing the cost and time required to achieve site closure.

Danielle Sylvia, Kurt Pennell, and Natalie Capiro, Department of Civil and Environmental Engineering, Tufts University, Medford, MA, 02155, Robinson 053E, 781-367-6064, Danielle.Sylvia@tufts.edu

Presenting Author: Danielle Sylvia