Geophysical Research Abstracts
Vol. 19, EGU2017-18616, 2017
EGU General Assembly 2017

Dissolution of a Tetrachloroethene (PCE) pool in an Anaerobic Sand Tank Aquifer System: Bioenhancement, Ecology, and Hydrodynamics

Sara Klemm, Jennifer Becker, and Eric Seagren
Michigan Technological University, Civil and Environmental Engineering, Houghton, United States (jgbecker@mtu.edu)

Dehalorespiring bacteria that reductively dechlorinate and grow on chlorinated ethenes in the aqueous phase can also achieve treatment of dense nonaqueous phase liquid (DNAPL) contaminants in the subsurface via bioenhanced dissolution, i.e., enhanced mass transfer from the DNAPL to the aqueous phase. Theoretical and experimental analyses predict that a number of interrelated physicochemical processes (e.g., advection and dispersion) and biological factors (e.g., biokinetics and competition) may influence the degree of bioenhancement. This research focused on understanding the interrelated roles that hydrodynamics and ecological interactions among dehalorespiring populations play in determining the distribution of dehalorespiring populations and the impact on bioenhanced dissolution and detoxification. The hypotheses driving this research are that: (1) ecological interactions between different dehalorespiring strains can significantly impact the dissolution rate bioenhancement and extent of dechlorination; and (2) hydrodynamics near the DNAPL pool will affect the outcome of ecological interactions and the potential for bioenhancement and detoxification. These hypotheses were evaluated via a multi-objective modeling and experimental framework focused on quantifying the impact of microbial interactions and hydrodynamics on the dissolution rate bioenhancement and plume detoxification using a model co-culture of *Desulfuromonas michiganensis* BB1 and *Dehalococcoides mccartyi* 195. The experiments were performed in a saturated intermediate-scale flow cell (1.2 m), with flow parallel to a tetrachloroethene (PCE) pool. Bioenhancement of PCE dissolution by the two dehalorespirers was evaluated using a steady-state mass balance, and initially resulted in a two- to three-fold increase in the dissolution rate, with *cis*-dichloroethene (cDCE) as the primary dechlorination product. Quantitative analysis of microbial population distribution and abundance using a 16S rRNA gene-based qPCR approach indicated that *Dsm. michiganensis* BB1 was the dominant population in the effluent. This was expected based on our previous work characterizing the PCE utilization kinetics of the two populations, and suggests that *Dsm. michiganensis* BB1 was the dominant population in the aquifer system and controlled PCE dissolution and its bioenhancement. This conclusion is consistent with our numerical modeling predictions for the same conditions, which suggested *Dhc. mccartyi* 195 had little effect on dissolution and dehalorespiration, but aided detoxification by growing on the cDCE produced by *Dsm. michiganensis* BB1. Subsequently, the PCE dissolution enhancement increased to six- to seven-fold relative to the abiotic dissolution rate. Quantitative analysis of population distribution and abundance in the porous media and nonreactive tracer studies suggested that microbial growth-induced bioclogging, coupled with inhibition of microbial activity near the DNAPL, resulted in increased flow immediately adjacent to the DNAPL-aqueous interface. The increased flow rate past the DNAPL could explain the observed increase in the PCE dissolution rate and is consistent with our numerical modeling of the system.

The research described here is part of a larger project working to improve the fundamental understanding of the impact of hydrodynamics and ecological interactions on DNAPL dissolution rate bioenhancement and plume detoxification. These biotic data build on the baseline abiotic experiments reported in another abstract submitted to Session HS8.1.6.