# Biologically Enhanced Mass Transfer of PCE from DNAPL Pools: Model Development and Evaluation at Intermediate Scales

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**Abstract.** High saturation pools of chlorinated DNAPL are long-term sources of groundwater contamination at many hazardous-waste sites. Traditionally, pools have been represented as aquifer zones with minimal advective transport and sharp changes in saturation at pool boundaries. Mixing of electron donor and acceptor, needed for active biodegradation, was thought to be limited by diffusion and lateral dispersion. Consequently, biotechnologies were expected to be ineffective for pool remediation and were not expected to enhance mass transfer. However, recent small-scale flow-cell experiments demonstrate that microbe-mediated reductive dehalogenation can enhance pool dissolution an order of magnitude while converting PCE to cis-DCE. Detailed saturation mapping and tracer tests show that significant advection occurs within transition zones at the top of pools. Reactive-transport modeling of these experiments indicates that electron-donor advection within transition zones promotes rapid PCE degradation and results in low aqueous-phase PCE concentrations. As a result, dissolution gradients within transition zones are greater than under abiotic conditions and mass transfer is enhanced.

The presentation will highlight results of large two-dimensional tank experiments conducted to evaluate this conceptual model at scales of practical interest. Results indicate that mass flux from source zones is significantly enhanced by biological activity. Biodegradation of PCE to cis-DCE occurs in the vicinity of pools and is followed by conversion to vinyl chloride and ethene a short distance downstream. Spatial distributions of PCE and biodegradation products show that degradation and DNAPL mass transfer is greatest along flow paths that traverse transition zones. These results suggest that biotechnologies can be effective remediation strategies for source-zone depletion while simultaneously treating down-gradient contamination. Efforts to characterize and model DNAPL depletion during bioremediation at field scales will need to recognize hydrodynamics within pool transition zones.