Prediction of ZVI-Clay Performance for Remediation of Chlorinated Solvent Source Zones

Mitchell Olson[1] and Tom Sale[2]
Department of Civil Engineering, Colorado State University, Fort Collins, CO 80523-1320

Abstract. ZVI-Clay is a remediation technology for subsurface chlorinated solvent source zones. The technology involves admixing reactive media (granular zero valent iron [ZVI]) and a stabilizing agent (Clay) using conventional soil mixing techniques. Benefits of the technology include contaminant depletion via ZVI-mediated reductive dechlorination and reduced hydraulic conductivity of the mixed zone. As such, contaminants are both chemically degraded and stabilized. ZVI-Clay was developed by DuPont, and is the subject of two patents donated to Colorado State University (CSU) by DuPont in 2003.

A field application of ZVI-Clay was completed in Martinsville, Virginia in 2002. Eight thousand cubic yards of soil, contaminated by up to 30 mg/kg carbon tetrachloride, were treated. Subsequent sampling results indicated that: 1) 99% degradation of chlorinated compounds was achieved, and 2) the bulk of degradation was completed within the first year. Limited information is available regarding reaction rates and mechanisms governing contaminant depletion. Building on this, a primary focus of current research at CSU is development of tools to predict performance of ZVI-Clay systems.

Mathematical models are the primary tools being considered for predicting ZVI-Clay performance. Concurrent with model development, batch-scale laboratory experiments have been conducted to test model predictions. Useful parameters obtained from modeling include: 1) bulk degradation kinetics, 2) kinetics and product yield for the reaction network, and 3) evaluation of the rate limiting step (i.e. diffusion in bulk media vs. reaction at iron surface). The bulk degradation rate can be calculated as a first-order irreversible reaction, with the reaction rate constant normalized to iron surface area. The kinetics and product yield of the reaction network are modeled using an analytical solution developed by Gerald Eykholt (1999). Finally, analysis of rate-limiting processes is conducted using both finite difference numerical techniques and dimensional analysis.

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[1] Master's Degree Candidate, Department of Civil Engineering, Colorado State University, Fort Collins, CO 80523-1320, mitcello@engr.colostate.edu
[2] Research Assistant Professor, Department of Civil Engineering, Colorado State University, Fort Collins, CO 80523-1320, saletm@engr.colostate.edu