Abiotic/Biotic Reduction of Trichloroethene and Perchlorate: Laboratory Treatability Study for a Superfund Site

Anca G. Delgado (anca.delgado@asu.edu), Srivatsan Mohana Rangan, Shefali Rao, Aatikah Mouti, and Rosa Krajmalnik-Brown (Arizona State University, Tempe, AZ, USA)
Gregory V. Lowry (Carnegie Mellon University, Pittsburgh, PA, USA)
Harry Brenton and Laurie LaPat-Polasko (Matrix New World Engineering, Phoenix, AZ, USA)

Background/Objectives. One of the challenges for implementation of in situ bioremediation of trichloroethene (TCE) is that it is often present at contaminated sites in mixtures with other pollutants. One such site is the Superfund Phoenix/Goodyear Airport North (Goodyear, AZ) where groundwater and soil contain TCE and perchlorate (ClO_4^-). Furthermore, the site aquifer is highly aerobic, poor in organic carbon, and little natural attenuation of the contaminants has been documented. A promising approach for this site is a combination of chemical reductants (e.g., zero-valent iron [ZVI]) and microbiological reductions. To test the feasibility of such approach, we designed a laboratory treatability study that evaluated an abiotic/biotic synergistic treatment of TCE and ClO_4^- using aerobic site groundwater and soil. The outcome of the treatability study provides valuable information for the potential design of remedial strategies at the Phoenix/Goodyear Airport North Superfund site.

Approach/Activities. We evaluated conditions representative of an injection zone containing ZVI with or without biostimulation/bioaugmentation and a downstream zone influenced by Fe (II) derived from ZVI oxidation. The experiments were setup as semi-batch microcosms and flow-through columns with site materials.

Results/Lessons Learned. In semi-batch microcosms and continuous flow-through soil columns representative of the ZVI injection zone, ZVI effectively decreased the oxidation-reduction potential of the groundwater and reduced TCE to ethene and ethane. However, the ClO_4^- concentration remained mostly unchanged. In microcosms, microbial reductive dechlorination of TCE was outcompeted by the ZVI abiotic reduction. Furthermore, ZVI inhibited the indigenous perchlorate-reducing bacteria. The H_2 generated by ZVI reactions was utilized by sulfate-reducing and methanogenic microorganisms. In the presence of high concentration of Fe (II) derived from ZVI oxidation, *cis*-dichloroethene (*cis*-DCE), vinyl chloride (VC) and ethene were microbially produced but at slower rates than in the absence of Fe (II). These data suggest an inhibitory effect by Fe (II) in semi-batch microcosms. In flow-through columns with a lower concentration of Fe (II), the inhibitory Fe (II) effects were mitigated. Thus, reductive dechlorination of TCE to ethene and ClO_4^- reduction was achieved and sustained as long as an electron donor was provided. Overall, these results illustrate the synergies and limitations of combining ZVI with microbial reductions and provide useful information relevant to remediation of sites containing multiple contaminants.