Bioremediation of 1,4-Dioxane, PCE, TCE, and Hexavalent Chromium: Bench-Scale and Pilot Test Studies

Vidhya Ramalingam (Vidhya.Ramalingam@tetratech.com) (Tetra Tech, Irvine, CA)
Jay Neuhaus (Jay.Neuhaus@tetratech.com) and
Alison M. Cupples (Cupplesa@msu.edu) (Michigan State University, East Lansing, MI)

Background: 1,4-dioxane, a probable human carcinogen, was commonly used as a solvent stabilizer and is frequently detected at sites contaminated with chlorinated solvents. Biodegradation of 1,4-dioxane contamination is challenging due to its solubility in groundwater and persistence. The objective of this presentation is to provide methodologies used, remediation results, and lessons learned with (1) a bench-scale microcosm study on 1,4-dioxane biodegradation, and (2) a pilot test involving in-situ application of chemical oxidation followed by anaerobic degradation for addressing 1,4-dioxane and chlorinated solvents at a former manufacturing facility in Southern California.

Approach and Evaluation: The bench-scale study was conducted with six inocula collected from agricultural soils, river sediments, and contaminated sites. Microcosms were spiked with 1,4-dioxane and aerobic biodegradation was observed in microcosms spiked with 1,4-dioxane. The sample microcosms were amended with 1,4-dioxane three times and the nucleic acid was extracted from the bacteria present. Further, the metagenomes were analyzed using whole genome shotgun sequencing.

The pilot test study was performed at a former latex product manufacturing facility in California. Previous analysis indicated VOCs including PCE and TCE, along with 1,4-dioxane and hexavalent chromium are contaminants of concern in groundwater at this site. In Situ Chemical Oxidation (ISCO) followed by Enhanced Reductive Dechlorination (ERD), using molasses and emulsified vegetable oil as carbon substrates, was implemented using direct push injections to address the contaminants of concern at the site.

Results and Conclusions: The results of the bench-scale study indicate 1,4-dioxane decreased in live microcosms with all six inocula, but not in the abiotic controls, suggesting biodegradation occurred. A comparison of live sample microcosms and live controls (no 1,4-dioxane) indicated nineteen genera were enriched following exposure to 1,4-dioxane, suggesting a growth benefit for 1,4-dioxane biodegradation. Eleven functional genes associated with 1,4-dioxane were found in the soil metagenomes. The work provides valuable insights into the identity of the multiple genera and functional genes associated with aerobic 1,4-dioxane biodegradation.

The results from the pilot test indicate a general reduction in the VOCs and hexavalent chromium following implementation of ISCO followed by ERD at the site. Some reduction of 1,4-dioxane concentrations was also observed following the implementation of ISCO but not following ERD. A discussion of the performance groundwater monitoring results and microbial evaluation based on both the studies will also be presented.