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SABRE Multi-Lab, Statistically Based Microcosm Study for TCE Source Zone Remediation

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SABRE (source area bioremediation) is a public/private consortium of twelve companies, two government agencies, and three research institutions whose charter is to determine if enhanced anaerobic bioremediation can result in effective and quantifiable treatment of chlorinated solvent DNAPL source areas. The focus of this 4-year, $5.7 million dollar research and development project is a field site in the United Kingdom containing a DNAPL source area with groundwater concentrations exceeding several hundred mg/L TCE.

Prior to field implementation, a large-scale, multi-laboratory microcosm study was performed to determine the optimal electron donor, supplemental nutrient, and bioaugmentation combination to support reductive dechlorination of TCE in site soil and groundwater. The study consists of 177 bottles (including unamended and sterile controls) distributed between four industrial laboratories (Dupont, GE, SiREM, and Terra Systems) and employs a statistically-based fractional factorial experimental design to test the impact of six electron donors (lactate, acetate, methanol, SRS (emulsified soybean oil), hexanol, butyl acetate), bioaugmentation with KB-1 bacterial culture, addition of supplemental nutrients (ammonia, phosphate, yeast extract), and two TCE levels (100 mg/L and 400 mg/L) on TCE dechlorination. Hexanol and butyl acetate are novel donors that have the potential to partition into the TCE DNAPL phase, creating a long-lived source of electron donor in the subsurface.

The microcosm study ran for 203 days. Total VOC mass balances incorporating TCE and daughter products in three phases (soil, water, headspace) within the microcosms were excellent. Statistical analysis of the data using analysis of variance (ANOVA) techniques was employed to determine both main effects and two- or three-way interactions for all the experimental variables. 121 (79%) of the amended bottles reached complete or near complete dechlorination of TCE to ethene by the end of the study. SRS was the most effective electron donor in promoting rapid and complete dechlorination, although it was not statistically better than methanol or lactate at a 95% confidence level. Bioaugmentation and nutrient addition had a statistically significant positive impact on TCE dechlorination. Twenty-nine bottles from the study were subsequently respiked with 800 mg/L TCE. Dechlorination was observed in roughly half the bottles after an additional 210 days. SRS was again the most effective donor in this follow-up study.

SRS, bioaugmentation, and nutrient addition have been selected for field implementation based upon these results. The data from this study will also be combined with microbial measurements (PLFA, DHC, DGGE) and subsequent column experiments to develop a comprehensive kinetic model of the dechlorination system.