Electrical Resistance Heating and Bioremediation: Compatibility, Effectiveness, and Post-Heating Bio-Polishing

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Background/Objectives. Electrical resistance heating (ERH) is a well-established technology for contaminant mass removal particularly in source areas. Traditional ERH operating temperatures (100°C) limit microbial activity in the source area. However, thermal treatment is often performed concurrently with bioremediation of the dissolved plume and recent evidence suggests the moderate heating (i.e., 35-45°C) experienced in downgradient areas may enhance biotic and abiotic degradation. Moreover, bio-polishing is often employed to reach closure levels in the source area after ERH deactivation suggesting that any adverse impacts on the microbial community may be temporary. In the current study, QuantArray was performed along with traditional groundwater monitoring to evaluate the impact of ERH operations on concentrations of halorespiring bacteria during startup, operation, and one year after ERH deactivation.

Approach/Activities. The site is a former dry cleaning facility impacted by tetrachloroethene (PCE), trichloroethene (TCE), daughter products, and Stoddard Solvent. An ERH system with 15 electrodes installed to depths of 45 feet below ground surface (BGS) was selected for contaminant mass removal in the 40-foot by 40-foot source area. Concurrent with thermal treatment, bioaugmentation was performed outside of the source zone. After 8 months, the ERH system was deactivated and confirmatory sampling was conducted to evaluate contaminant mass removal. Throughout the project, groundwater samples were periodically obtained for VOCs analysis and QuantArray quantification of halorespiring bacteria (e.g., *Dehalococcoides*) and functional genes (e.g., vinyl chloride reductase).

Results/Lessons Learned. Overall, ERH was very effective in reducing contaminant mass in the source area. Soil PCE concentrations decreased from as high as 170 mg/kg to less than 0.02 mg/kg in all post-ERH soil samples while groundwater PCE, TCE and cis-1,2-DCE concentrations decreased by one to two orders of magnitude. Throughout the project, QuantArray revealed impacts of temperature increases, differences, maximums, and decreases on halorespiring bacteria. Prior to ERH, total bacteria were on the order of 10^6 cells/mL and populations of *Dehalococcoide*s and other halorespiring bacteria were moderate (10^2 to 10^3 cells/mL). During the 2 months of ERH as temperatures increased to 50-60°C, *Dehalococcoides* populations decreased substantially, but concentrations of other halorespiring bacteria including *Dehalobacter* spp. did not appreciably decrease. Over the next 6 months of operation, sustained temperatures of 70 to 100°C were reached at shallow depths and microbial populations continued to decline. Due to the presence of more permeable geologic strata however, temperatures at intermediate depths (35-45 feet BGS) remained moderate (40-60°C) throughout ERH operation. Although microbial populations also decreased for the intermediate depths, halorespiring bacteria were still detected even after 8 months of ERH operation. One year after ERH shutdown, concentrations of total bacteria, *Dehalobacter* and *Desulfitobacterium* spp. had rebounded to near or greater than pre-ERH levels. *Dehalococcoides* concentrations however remained below detection limits. While bioaugmentation may be necessary in this case, the maintenance of halorespiring populations at moderate temperature and microbial recovery following elevated temperatures have important and encouraging implications for implementing

bioremediation following ERH, biodegradation in adjacent areas during ERH operation, and for biodegradation in a source zone while undergoing moderate temperature ERH.