The Influence of Electrokinetic Bioremediation on Subsurface Microbial Communities in Perchloroethylene-Contaminated Soil

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Background/Objectives. In situ bioremediation of chlorinated contaminants via bioaugmentation is often used as an effective remedial strategy at contaminated sites. However, successful bioremediation can be hindered at locations with complex geology and low-permeability soils where it is difficult to effectively deliver the required culture and amendments. In situ electrokinetic-enhanced bioremediation (EK-Bio) is a novel alternative that can improve transport of required bioaugmentation amendments at these challenging sites. Transport of ionic compounds via EK-Bio can achieve uniform distribution of required compounds and increase bioremediation performance. Geosyntec Consultants has demonstrated the effectiveness of this technology from the laboratory to pilot and full-scale applications. While previous evaluations of this technology have investigated its effect on native microbiota via soil respiration measurements, colony counts or substrate utilizations rates, our aim was to look more deeply and investigate its effect on native microbial communities' structures and functions using next generation sequencing (NGS) techniques. This investigation can yield information about the long-term changes in microbial ecology and soil health as well as potential strategies for optimizing the technology.

Approach/Activities. Geosyntec Consultants completed a pilot test of EK-Bio at a site in Jacksonville, Florida, contaminated with perchloroethylene (PCE). The contaminant source was 6 to 8 m below the ground surface in a clay soil under an active parking lot. An EK-Bio system was constructed with nine electrode wells to apply direct current and eight supply wells to deliver bioaugmentation amendments. Groundwater samples were collected from monitoring wells during active system operation, and additional groundwater and soil samples collected several months after the operation ceased. DNA was extracted from these samples with the Zymo Universal DNA kit, and 16S rRNA gene amplicons were sequenced with Illumina Miseq.

Results/Lessons Learned. At the completion of active EK-Bio operation, PCE concentrations decreased by more than 80% along with associated increases in ethene, *Dehalococcoides, Dehalobacter* and vinyl chloride reductase genes (vcrA). Sequencing results revealed an enrichment of several bacteria in the treatment zone including the PCB/chloro-organic pesticide degrading *Alcaligenaceae* and *Burkholderiaceae* (>65% enrichment), sulfate reducing bacteria *Syntrophaceae* and *Syntrophobacteraceae* (>17% enrichment) and metal and chlorinated solvents reducing bacteria Geobacteraceae (>24% enrichment). Some of this enrichment may be due to the contamination itself, others may be correlated with changes in soil geochemistry associated with EK-Bio. Results also indicate alpha diversity (mean local species diversity) of the samples from the treatment zone increased from that in samples from up-gradient background location. This increase in diversity was maintained several months after active operation ceased. The results suggest that future applications should carefully consider site geochemistry (e.g., high nitrate or sulfate concentrations) which may create a more competitive microbial environment in the treatment zone. This investigation shows that EK-Bio application at this site resulted in increased microbial diversity in the treatment zone and, thus, improved soil microbiota health supporting the objective of enhanced in situ bioremediation.