Comparison of Bioremediation of Biosparge Systems from Two Sites

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Background/Objectives. Decreasing methane production, increasing dissolved oxygen (DO) concentration, and aerobic microbial response are leading and lagging indicators for the effectiveness of aerobic bioremediation. However, achieving uniform responses across the site highly depends on site geology and remedy delivery. The focus of this presentation is to review the complexities of site conditions at two active industrial petroleum sites in Southern California and compare microbial community responses to oxygen levels depending on differences in hydrogeologic settings, operating conditions, and baseline contamination levels. The main chemicals of concern (COCs) are LNAPL and dissolved-phase BTEX concentrations.

Approach/Activities. Biosparge systems were designed and constructed under stringent engineering requirements and utilized different approaches to the remediation technology implementation; one using mechanical and electrical power sources and equipment and computer-based controls and the other using solar power and external plant compressed air. Since the system's regular operations began, system parameters, including flow rates and pressures at the main header, branch lines, and sparge wells, were recorded and modified during weekly site visits. Performance monitoring was conducted at groundwater monitoring wells. Field monitoring events were performed to measure fluid levels, DO concentrations, oxidation-reduction potential (ORP), temperature, pH, and electrical conductance in groundwater. Groundwater samples were collected at each site, prior to system startup (i.e., baseline) and 12, 24, and 48 weeks following startup (i.e., performance evaluations) for laboratory analysis of COCs. Microbial Bio Traps® were collected at baseline and six to twelve weeks post startup for laboratory analysis of functional genes responsible for both aerobic and anaerobic biodegradation of petroleum hydrocarbons using the QuantArray®-Petro quantitative polymerase chain reaction (qPCR) method.

Results/Lessons Learned. For the biosparge system operated on mechanical and electrical power, the pressure response at the sparge wells ranged from 9 to 16 pounds per square inch (psi) and had an average flow rate of 1.1 standard cubic feet per minute (scfm), whereas for the solar-powered and plant air biosparge system, the pressure at the sparge wells ranged from 16.5 to 60 psi and had an average flow rate of 2.5 scfm. The differences in the pressures and flow rates between the two sites are primarily driven by the difference in depth and hydrostatic pressure on sparge screens. At both sites, in response to the sparging flow rates and pressures, the changes in fluid elevations at the monitoring wells fluctuated from +4.2 to -3.4 ft and, in wells with historically-persistent LNAPL, the LNAPL thickness decreased to zero. The increase in DO concentrations correlated with the magnitude of flow rates, effective zone of sparging influence and the permeability of the formation. The DO concentrations ranged from 2.4 to 28 mg/L (i.e., saturation levels) at the solar-powered system, and from 1.90 to 4.88 mg/L for the mechanical system. A significant difference was observed in the microbial communities correlating to decrease in the dissolved BTEX concentrations at both sites. However, the reduction in dissolved BTEX concentration was not uniform across the site and was dependent on heterogeneities of the local geology. The COC degradation efficiency can be increased by developing a coherent site model to identify and optimize the sparge well-specific operating parameters.