Evaluation of Sulfolane Biodegradation Enhanced Using Biosparging in a Fractured Rock Aquifer

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Background/Objectives. Sulfolane is an emerging issue at former oil and gas sites with chemical properties that promote transport in the environment including high solubility, low sorption potential and low volatility. Biodegradation of sulfolane under aerobic conditions has been demonstrated in numerous laboratory and field-scale studies. As such, establishing the intrinsic capacity for biodegradation of sulfolane and evaluating remedial strategies to enhance sulfolane biodegradation is a critical component of full-scale remedial design. An enhanced biodegradation strategy using a biosparging approach to mitigate sulfolane impacts in bedrock groundwater was applied to a former natural gas plant located in Canada. Previous investigations identified the occurrence and extent of a large, dilute groundwater plume comprised of sulfolane. A biosparging field-scale study was conducted to evaluate the effectiveness of introduction of oxygen (via air injection) to promote aerobic conditions in the subsurface and enhance intrinsic sulfolane biodegradation processes. State of the art molecular biological analyses were employed in concert with traditional data analyses to evaluate the effectiveness of this strategy to create biogeochemical conditions that promote sulfolane biodegradation.

Approach/Activities. Biosparging air injections were performed at varying rates and pulsing frequencies in six injection wells installed in shallow bedrock (target depth was 11 to 17 meters below ground surface) to increase dissolved oxygen concentrations in the treatment area above 2 mg/L. Total bacteria (heterotrophic plate counts), sulfolane degrading bacteria, qPCR, next generation sequencing (NGS) analyses were performed on groundwater samples to monitor the effects of biosparging on the microbial population and sulfolane-degrading activity. Sulfolane-degrading microorganisms were also isolated using plate techniques. Additionally, chemical analyses of sulfolane, dissolved oxygen and biogeochemical parameters (dissolved carbon dioxide, total organic carbon, electron acceptors) were conducted to evaluate the effects of biosparging on biogeochemical conditions within the treatment area.

Results/Lessons Learned. Quantification of sulfolane-degrading bacteria and total bacteria demonstrated there was an increase in sulfolane-degrading bacteria above baseline levels over time across the treatment area. Additionally, the ratio of sulfolane-degrading bacteria to total bacteria increased during treatment demonstrating that the population of sulfolane-degraders increased more quickly than other bacteria. *Acidovorax* species were confirmed as sulfolane degrading bacteria when isolated from a specific sulfolane culture media. NGS analyses indicate species of *Acidovorax* genus were found in each of wells within the treatment area. Chemical analyses demonstrated that aerobic biogeochemical conditions favorable for sulfolane biodegradation were enhanced by the air injections across the treatment area. As a result of enhanced aerobic conditions and microbial growth and activity, sulfolane concentrations in groundwater decreased significantly during the pilot study, and the majority of sulfolane reduction (50% to more than 99%) was achieved within the first months of biosparging operation. The multiple lines of evidence approach used to evaluate remediation performance and demonstrate enhanced, intrinsic reduction of sulfolane will be presented, including a focus towards development of remedial strategies for plume treatment.