Bioremediation Monitoring Optimization to Key Bioremediation Indicators: KBI on a Large-Scale Recirculation System for a Thermal-Enhanced Anaerobic Process

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Background/Objectives. An industrial facility operated in Sao Paulo, Brazil from 1980 to 1993. Chlorinated solvents (PCE) were released from the site and other properties, resulting in soil and groundwater contamination from multiple sources. A combination of remediation technologies were implemented for the Site to: 1) contain plume migration with a downgradient hydraulic barrier; 2) soil vapor extraction for vadose zone source removal and; 3) source and dissolved plume remediation with a thermally-enhanced anaerobic recirculation system (ISB system) utilizing multiple recirculation cells oriented parallel and perpendicular to the ambient hydraulic gradient. The ISB system was implemented in 2015 with a systematic approach that began with a small field pilot test comprising one recirculation loop and lactate addition to stimulate complete reductive dechlorination of PCE. Following the success of the pilot test, the ISB system was expanded in 2016 to multiple upgradient areas with five recirculation loops approximately 1,200 square meters. In 2017, the ISB system was again expanded to cover the entire site dissolved plume another 3,200 square meters in area, using four recirculation transects while maintaining the hydraulic barrier control.

The ISB system comprises 44 monitoring locations. Performance of the initial pilot test and upgradient recirculation loops using an extensive analyte list - including determinations of PCE its degradation products (compounds of interest; COI), terminal electron acceptors (TEA), dissolved hydrocarbon gases (DHG), total organic carbon (TOC), *Dehalococcoides* and its functional genes via qPCR and compound-specific isotope analysis together with field parameters. The aim of this work is to demonstrate that after the initial ISB operation and monitoring, it was possible to optimize the monitoring program to key bioremediation indicators (KBIs) that provide sufficient feedback for making remediation decisions.

Approach/Activities. During pilot tests and upgradient system operation several operational configurations regarding lactate solution injection (e.g., injection time variations and determination of TOC half-life) set up the basis to define KBI as COI, TOC and DHG. TOC provide information on substrate availability to sustain ISB, ethene and ethane provide a quantitative metric for complete dechlorination of COI and methane concentrations informed on proper reducing conditions. COI coupled with DHG provide unequivocal evidence for mass reduction. Operation decisions based on KBI were facilitated using automatically updated cloud-based dashboards to evaluated by the team.

Results/Lessons Learned. By limiting monitoring to KBI, monitoring costs were reduced by approximately 15% while remediation goals (SSTL) have already been achieved at 90% of the monitoring points, with more than 40% of them reached legal standards (drinking water standards). Next steps are to evaluate when the recirculation system can be shut down to facilitate a transition to MNA (with continued monitoring of KBI).