

Optimizing Injection and Monitoring of Bioaugmentation Cultures for In Situ Bioremediation

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Background/Objectives. Bioaugmentation has been around for more than two decades and can be considered a “classical” bioremediation technology. There have been several improvements made over the years to optimize this classical technology. Successful enhanced in situ bioremediation (EISB) remedies rely on the effective delivery of amendments to optimize conditions where microbial populations can thrive and degrade contaminants of concern. Traditionally, electron donors were added to an aquifer and allowed to ferment for weeks to months to create reducing conditions suitable for anaerobic bioaugmentation cultures. New methods allow preparation of high-quality anaerobic injection water used to disperse electron donors and bioaugmentation cultures simultaneously, saving time and money and increasing the effectiveness of bioremediation.

Advances in bioaugmentation culture production now allow cultures to be concentrated prior to shipping. Concentration removes excess water and produces a higher cell concentration, reducing shipping costs and the logistics of handling multiple vessels in the field. EISB performance monitoring includes volatile fatty acids (VFAs), dissolved hydrocarbon gases (DHGs), molecular genetic testing, and compound specific isotope analysis (CSIA). These tests can be used, along with standard field parameters (i.e., pH, ORP, DO, VOCs, metals, anions), to monitor the distribution, geochemical impacts and EISB performance after electron donor and concentrated bioaugmentation cultures are co-injected with anaerobic water.

Approach/Activities. EISB amendments can be applied by numerous approaches including injection wells, direct push, groundwater recirculation systems, horizontal wells, infiltration galleries and high-pressure injection techniques. With all these methods, concentrated culture can be co-applied with the electron donor amendments using anaerobic water. The reduced volumes used with concentrated culture required the development of small volume injection dispensing tools to effectively deliver the culture to the aquifer under anaerobic conditions. A range of methods has been developed to inject concentrated culture while utilizing various injection approaches, including protocols to inject culture into aerobic groundwater while protecting anaerobic bacteria. Post-bioaugmentation monitoring parameters are typically collected 3 months after bioaugmentation and then quarterly. These parameters are used to track the distribution and performance of the amendments including confirming that the bioaugmented microbes are increasing in abundance.

Results/Lessons Learned. Volumes of bioaugmentation culture are typically small (e.g., 250 mL to 1 L/location) compared to the electron donor and chase water volumes, making the accurate measurement of the culture volume per point critical. The development of small volume injection dispensers and suitably prepared anaerobic water were key to effectively inject concentrated culture. This presentation will highlight different approaches for applying small volume concentrated cultures using anaerobic water and present post-bioaugmentation monitoring results with a focus on VFAs and molecular genetic analysis which were used to confirm the successful addition of the amendments and to diagnose situations where additional actions may be required to optimize performance.