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From the Lab to the Field – Demonstrating Bioaugmentation In Situ to Enhance Anaerobic Benzene Biodegradation

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Intrinsic anaerobic processes impact the fate of benzene, toluene, ethyl benzene and xylenes (BTEX) as well as other petroleum hydrocarbons at contaminated sites. Recent research has shown that anaerobic bioremediation processes are viable options for plume control and site cleanup for BTEX. Benzene, the most toxic of these compounds, is much more of a challenge for bioremediation, because the requisite microorganisms are relatively difficult to grow, and reaction mechanisms are still not well understood. Thanks to genomics, the microorganisms responsible for benzene transformation have been identified and bioaugmentation cultures are now being grown in large volumes sufficient for field application.

Several benzene degrading cultures have been identified, including a methanogenic benzene enrichment culture (DGG-B), developed at the University of Toronto, which transforms benzene under either methanogenic and sulfate reducing conditions. Its key degrader Deltaproteobacteria ORM2 has been identified. Laboratory treatability studies have demonstrated that bioaugmentation with the DGG-B culture is effective and has been demonstrated to degrade up to 20 mg/L benzene at accelerated rates over natural attenuation. Furthermore, the presence of benzene degrading biomarkers can be correlated to benzene biodegradation activity and is being used to track these microorganisms in groundwater.

The first field application of the DGG-B bioaugmentation culture is planned for summer 2019, at a site in Saskatchewan with several other sites to follow. The use of bioaugmentation cultures in Canada requires approval under the New Substances Notification process under the Canadian Environmental Protection Act to ensure the safety and effectiveness of these products and an application is currently in progress.

Results from treatability studies including the upcoming field sites demonstrated enhanced benzene biodegradation rates using DGG-B and provided information to aid in field pilot test design. One field pilot test will include 3 injection points, two of which will receive up to 10 liters of DGG-B culture, while killed culture will be applied at the third; which will serve as a control to determine if dead cells promote any degradation. It is anticipated that benzene degradation rates will be accelerated as observed in the treatability studies. These first to field projects will establish clear guidelines and approaches for using these novel bioaugmentation cultures. Bioaugmentation has potential to decrease remediation time frames and to provide a much-needed cost effective alternative for BTEX remediation in groundwater.

This is particularly exciting because for many of the sites in question viable alternative remediation approaches simply do not exist.

Sandra Dworatzek, MSc

Ms. Dworatzek is an environmental microbiologist with advanced technical experience in laboratory treatability studies. Over the past 25 years she has conducted and overseen numerous bench-scale studies examining enhanced in situ bioremediation in groundwater. She has specific technical experience in the design of laboratory treatability studies, the scale up of growth of aerobic and anaerobic microbial cultures for bioaugmentation laboratory and field pilot tests, and evaluation of aerobic and anaerobic bioremediation, zero valent iron and chemical oxidation technologies in the laboratory.

Ms. Dworatzek is a Principal Scientist at SiREM, a division of Geosyntec Consultants and has been with the company for seventeen years. SiREM maintains state-of-the-art treatability, molecular testing and microbial culture production facilities. She currently oversees maintenance and culturing of KB-1® and KB-1® Plus dehalorespiring microbial cultures that have been widely used in field demonstrations to improve the rate and extent of bioremediation of chlorinated solvents in groundwater (e.g., tetrachloroethene (PCE) and trichloroethene (TCE) dechlorination to ethene), as well as the development of new bioaugmentation cultures including 1,4-dioxane, 1,2,3-trichloropropane, benzene, toluene and xylene. She provides technical oversight for treatability studies for a wide range of environmental contaminants, including halogenated organics (e.g., solvents, pesticides, etc.) and petroleum hydrocarbons both alone and in complex mixtures.