Phased Lab-to-Field Bioremediation Amendment Screening for Cleanup of Explosives-Contaminated Groundwater

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Background/Objectives: Ordnance disposal at the Naval Base Kitsap Bangor, located in Silverdale, Washington, Site A (Site A) resulted in hexahydro-1,3,5-trinitro-s-triazine (RDX) contamination in two aquifers. The perched aquifer saturated interval is in the range of 10 to 17 ft below ground surface (bgs) during the rainy season (winter – spring) but is otherwise dry. The shallow aquifer saturated thickness is in the 65 to 105 ft bgs range and exhibits minor water level seasonality. The perched and shallow aquifers are separated by a 10 to 15 ft thick layer of till. Maximum RDX concentrations detected in perched zone and shallow aquifer groundwater in spring 2016 were 120 and 170 µg/L, respectively. An activated carbon treatment system was utilized to treat soil washing leachate (1994-1999) then to treat groundwater as part of a pump & treat system for the shallow aquifer (1999-present). In situ bioremediation (ISB) is being considered for optimizing the inefficient pump & treat groundwater remedy at Site A. During ISB bioremediation, amendments are added to stimulate anaerobic microbial activity, which has been shown to effectively reduce commingled explosives contamination including RDX and TNT in groundwater. Bioremediation amendment effectiveness can vary by site and by aquifer. Accordingly, in order to increase confidence in the bioremediation substrate selected for field trials, a laboratory microcosm bioremediation amendment screening was conducted using aquifer material from both Site A aquifers. Initial aquifer characterization tests were performed in parallel to in support design of in situ bioremediation field trial.

Approach/Activities: Bioremediation screening microcosms were prepared by combining groundwater (150 mL) and aquifer material (15 g) from each zone in a serum bottle, then adding one of the following amendments to achieve a minimum initial carbon-normalized concentration of 150 mM: molasses, fructose, acetate or whey. Redox conditions were monitored in the microcosm bottles prior to spiking in RDX (1 mg/L) and measuring its disappearance over time. Borehole dilution tests were performed in perched zone and shallow aquifer wells to obtain groundwater seepage velocity estimates, followed by a series of short-duration push-pull tests (PPTs) in the same wells to quantify aquifer-specific RDX retardation factors.

Results/Lessons Learned: Amendments achieved varied redox endpoints, which appeared to govern rate of RDX transform observed in the laboratory microcosms. Perched zone aquifer microcosms that received molasses, fructose or whey exhibited redox potentials of -401 mV or less prior to spiking RDX; rapid RDX transformation was observed. Acetate-amended perched zone aquifer microcosms exhibited redox potentials of +43 mV or greater prior to spiking RDX; negligible RDX transformation was observed. Shallow aquifer microcosms that received molasses or whey exhibited redox potentials of -504 mV or less prior to spiking RDX; significant RDX transformation was observed. Acetate- and fructose-amended shallow aquifer microcosms exhibited redox potentials of -326 mV or greater prior to spiking RDX; negligible RDX transformation was observed. The basis for bioremediation amendments recommended for using during the field trial will be presented, along with initial results of the bioremediation field trial at Site A.