Performance Comparison of Three Different Treatment Technologies for In Situ Remediation of a 1,4-Dioxane Plume in a Heterogeneous Aquifer

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Background/Objectives. The goal is active remediation of a plume of 1,4-dioxane (40 to 70 feet below ground surface) in a heterogeneous aquifer in the Georgetown neighborhood of Seattle, Washington. This aquifer consists of discontinuous interbedded fine sand, silty sand, and sandy silt lenses with an estimated linear groundwater velocity of approximately 90 feet per year. The conceptual model for 1,4-dioxane transport is slow release from the low permeability units within the aquifer, which are acting as a secondary source (no primary source of 1,4-dioxane remains).

Treatment of 1,4-dioxane by in situ chemical oxidation (ISCO) has typically been by pressurized injection of advanced oxidation chemicals, but these methods only work when the oxidant is able to physically contact the contaminant. Even with repeated pressurized ISCO injections, if there are other oxidant scavengers present (iron, total organic carbon, etc.) the oxidant is unlikely to permeate the low permeability units or persist long enough to significantly reduce the mass of 1,4-dioxane. Overdosing the oxidant in an attempt to overcome oxidant scavengers may also lead to mobilization of heavy metals or release of other byproduct chemicals.

Given the limitations and complexities of typical pressurized injection of ISCO for treatment of 1,4-dioxane in heterogeneous aquifers, two additional treatment technologies are currently being pilot tested: slow release of chemical oxidant via wax candles and in situ biodegradation (ISB). A slow sustained release of oxidant may spread more uniformly to areas bypassed under pressurized injections of oxidant and reduce the need for repeat injections. Recent studies have found that there are microorganisms capable of degrading 1,4-dioxane in situ. This possibility reopened evaluation of bioremediation (specifically envisioned as flow through biobarriers) as an alternative treatment option.

Approach/Activities. The ISCO bench-scale study was completed in 2015 and results indicated that unactivated persulfate would be an effective oxidant. A single pilot scale pressurized injection of persulfate was performed in 2016. Two additional treatability paths were pursued: 1) sustained release ISCO pilot-scale testing and 2) ISB pilot testing including a laboratory-based microcosm study to isolate indigenous 1,4-dioxane degrading microorganisms and assess bioaugmentation of the aquifer with a follow-up in situ pilot test program. In situ pilot studies began for both technologies in 2017 and monitoring will conclude in the fall of 2018.

Results/Lessons Learned. Pilot-scale pressurized injections of persulfate did result in decline of 1,4-dioxane concentrations, but overall results were hard to quantify, due to limitations of distribution and measurement in a heterogeneous aquifer. The microcosm study was completed in 2016 and did not identify statistically significant evidence pointing to indigenous organisms capable of degrading 1,4-dioxane. However, the microcosms bioaugmented with *Pseudonocardia dioxanivorans* CB1190 and *Mycobacterium* sp. PH-06 did display robust 1,4-dioxane degradation. The majority of pilot test results for sustained release ISCO and ISB will be available by April 2018, and the results of all three pilot-scale studies will be compared (including projected differences in full-scale treatment costs.)