Stimulating and Quantifying TCE Biodegradation in Multiple Fractured Bedrock Strata

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Background/Objectives. TCE is present in a thick sequence of fractured bedrock under an industrial site in upstate New York. The bedrock consists of multiple carbonate units overlying a deeper, highly transmissive, gypsum-rich unit (the "D3" unit). A pilot test began in July 2013 and involved injections in a known TCE source area where DNAPL is believed to have migrated to the D3 unit. The six injection wells were screened in the upper intermediate bedrock (the "I1" unit). The objectives were to assess the treatment of TCE at concentrations in excess of 100 mg/L in the I1 unit, and assess the ability to impact groundwater conditions in the deeper D3 unit. The pilot study was subsequently expanded to include a second DNAPL source area, which involved seven additional I1 injection wells.

Approach/Activities. In the original source area, a total of 37,000 kg of potassium lactate and 650 kg of EVO have been injected into the six wells during three injection events. The potassium lactate was injected as a full strength (60%) solution, with a density of 1.33 g/mL, to augment the downward migration in response to the large vertical hydraulic gradients.

In the second source area, a total of 5,270 kg of potassium lactate and 3,120 kg of EVO have been injected into the seven additional I1 injection wells beginning in November 2016. As before, the EVO injections were used to support reductive dechlorination of TCE in the I1 unit, and the lactate was intended to impact groundwater conditions in the deeper D3 unit. In addition, based on the results of microcosm and column studies (Harkness et al., 2017), 6,080 kg of colloidal magnetite and 0.8 kg of vitamin B12 were injected to impact the D3 unit.

Results/Lessons Learned. We have now completed more than four years of monitoring for the original pilot test, and several monitoring events since expanding the pilot to the second source area. Reductive dechlorination of TCE is being observed in the I1, but dissolution of TCE from residual DNAPL and back diffusion from the rock matrix complicate the assessment of biodegradation based solely on TCE concentrations. In addition, injection of concentrated potassium lactate without follow-up EVO injections appeared to create some temporary inhibition of the reductive dechlorination process. Monitoring of daughter products, use of sodium and chloride data, and CSIA were critical tools to document reductive dechlorination in the I1 unit, even in wells where TCE concentrations did not decline significantly.

Monitoring results demonstrated that injection into the I1 unit impacted groundwater conditions in the D3 unit. VFA and TOC concentrations in the D3 wells located about 35 m deeper and 250 m downgradient from the I1 injection wells began increasing about six months after the initial injections. However, the presence of electron donor alone was not sufficient to stimulate significant reductive dechlorination of TCE in the D3 unit, which contains high levels of sulfate. Laboratory studies showed that iron and vitamin B12 are also necessary to enhance reductive dechlorination under these conditions (Harkness et al., 2017). This pilot test represents the first attempt to inject CMAG and elevated amounts of vitamin B12 into the subsurface. The presentation will provide updated results on the pilot test performance monitoring, including the first full year after expansion to the second source area and injection of the CMAG and supplemental vitamin B12.