Successful In-Situ Chemical Reduction of High Explosives in Groundwater

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Groundwater contamination by high explosives (HE) such as RDX and TNT poses great challenges for environmental remediation. In situ remediation activities are ongoing at the U.S. Department of Energy (DOE) Pantex Plant, located in Amarillo, Texas, which include in situ chemical reduction targeted as a groundwater reactive barrier. This paper describes the design, field application, and treatment results of two phases of field application of chemical reduction barrier, one involving sodium dithionite as the chemical reductant, and the other involving calcium polysulfide.

The first phase of reactive barrier application was a chemical reduction barrier involving the injection of sodium dithionite to create a chemically reduced zone in the subsurface.

The sodium dithionite acts to reduce naturally occurring iron in the subsurface to Fe^{2+}.

The Fe^{2+} is immobilized within the aquifer matrix, and serves as a semi-permanent reductant that treats HE migrating in groundwater, and this project is the first field-scale application of ISRM technology for high explosives treatment. The field-scale design for ISRM implementation was based on site hydraulics, on reduction reaction stoichiometry, and on reactive transport characteristics of the sodium dithionite. Two dithionite injection wells were used to create a pilot-scale reactive barrier. The sodium dithionite ISRM barrier resulted in effective treatment of HE and other constituents in groundwater. However, sever reaction-limitations on the sodium dithionite delivery were observed during the initial application of chemical reductant, which limited the well spacing achievable for injection wells.

A second reactive barrier was constructed using calcium polysulfide, to provide a comparison to the dithionite barrier. Bench testing of both dithionite and polysulfide chemical reduction was conducted prior to field application. The bench test results showed that calcium polysulfide was roughly four-fold more effective than dithionite at reducing the native soil iron, and that polysulfide-reduced soil columns were at least three-fold more effective than dithionite-reduced soil columns at eliminating RDX from groundwater. The field results confirmed that the slower reaction rates of calcium polysulfide resulted in greater persistence and lateral transport away from injection wells. Results of ongoing monitoring of the calcium polysulfide barrier are presented.