Effect of Dissolved Organic Carbon on Performance of ZVI-Based Remediation

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Background/Objectives. The feasibility of remedial applications of zero-valent iron (ZVI) for treatment of chlorinated solvents in groundwater is governed by two key geochemical factors: (i) the type of the targeted compounds of concern; and (ii) the presence of specific chemical constituents which may affect the ZVI reaction chemistry and longevity. In regard to the latter, there is currently a good understanding on the influence of inorganic constituents such as carbonate alkalinity, nitrate, silica and sulfate on the ZVI performance. However, the effects of various types of dissolved organic carbon (DOC) on ZVI reactivity is still unclear. In previous ZVI testing performed by SiREM and others, high DOC concentrations in some site groundwaters have caused negative impacts on ZVI degradation (i.e., lower VOC degradation rates), while other sites with high DOC water have shown no impact whatsoever. Published results have shown that the DOC impact on ZVI degradation rates was compound-specific and dependent on the composition and levels of the DOC fractions (i.e., humic vs. fulvic acids). Mixtures of ZVI and other amendments commonly used in remedial applications, such as guar gum, lactate, plant derived carbon, emulsified vegetable oil, containing degradable organic carbon are expected to create dissolved carbon; therefore, additional understanding of synergies and interferences between ZVI and DOC is needed.

Approach/Activities. Results of SiREM's flow-through column testing using granular ZVI and microscale ZVI with site groundwaters containing various concentrations of DOC will be presented, with an emphasis on the effect on the first-order degradation rates and the temporal loss of reactivity. The results will include side-by-side tests for different types of ZVI and ZVI-carbon combinations. The internal results and relevant published data will be analyzed and categorized in terms of the anticipated effect on ZVI performance from various forms of authigenic and exogenic DOC.

Results/Lessons Learned. The results from ZVI testing with various site groundwaters have shown that natural DOC present at concentrations of less than 5 mg/L generally does not pose adverse effects on ZVI reactivity. Guar gum, used as a liquid shoring for trenching ZVI permeable reactive barriers or for creation of pumpable slurry of ZVI injections, has been shown to have intermittent adverse effects on ZVI reactivity due to deposition on ZVI grains. However, the reactivity recovers gradually and DOC created by guar gum biodegradation does not affect ZVI. Emulsified vegetable oil tested in a denitrification column to remove nitrate prior to treatment in a ZVI column resulted in substantial improvement in reaction rates, compared to a ZVI column receiving the same site water containing nitrate. A parallel ZVI column test using groundwater with and without sodium lactate resulted in similar VOC degradation in both columns. The results underscore the importance of site-specific treatability testing for remedial applications of ZVI-based amendments using site groundwaters.