

Keys to Successful In Situ Chemical Reduction (ISCR) of Hexavalent Chromium and Concomitant Geochemical Fixation of Associated Heavy Metals and Metalloids

Jim V. Rouse (jrouse@acuityes.com) (Acuity Environmental Solutions, Golden, CO, USA)
Dr. Richard Christensen (rchristensen@acuityes.com) and
Andrea Parra De Jesudian (ajesudian@acuityes.com)
(Acuity Environmental Solutions, Fishers, IN, USA)

Background/Objectives. One of the most common anion-mobile toxic metal contaminants subject to in situ chemical reduction (ISCR) is hexavalent chromium (Cr(VI)), but such ISCR has the potential for the enhanced mobilization of other metals and metalloids, such as arsenic, selenium, manganese and nickel. Experience at various sites has demonstrated that successful ISCR involves two key considerations: 1. Selection of the most effective reductant, considering site geochemistry, and 2. Selection of the best reductant delivery system, considering site geohydrology. Keeping in mind that ISCR is a 'contact sport', a phased approach has been developed with the objective of meeting both these considerations, at the same time minimizing or eliminating the geochemical mobilization of other, potentially mobile contaminants.

Approach/Activities. The first key to success, selection of the appropriate reductant, first involves conducting screening-level natural reductant demand (NRD) tests using various reductants and contaminated water and soil from the site. The objective of these tests is to determine the dose rate needed to achieve generation of a reduced oxidation/reduction potential (ORP) sufficient to reduce Cr(VI). Since little Cr(VI) is commonly sorbed onto site soil but rather is dissolved in interstitial water, it frequently is necessary to use pressure / vacuum lysimeters to obtain the needed water from the vadose zone. The second step is conducting bench-scale tests with various doses of the more promising reagents, on slurries of site soil and water, to develop data on the required dose rate and effectiveness for chromium reduction and other potential reagents. Field pilot tests may then be required. The second key to success, selection of the delivery method for the reductant, is dependent of geohydrological factors such as horizontal and vertical permeability and its variability. Successful systems have used surface infiltration, hydraulic fracturing, soil mixing, and many other approaches. The advantages and disadvantages of many delivery systems are discussed with case examples.

Results/Lessons Learned. The senior author first conducted ISCR on a Cr(VI) site in Northern Indiana in the mid 1980s. The site had been the location of a 'pump and treat' operation for over a decade, but the in situ operation cleaned the site in less than 2 months. Calcium polysulfide was used as the reductant. No mobilized arsenic was detected due to the low amount of it on the subsurface. Plugging of the injection system was the main problem to overcome. The first use of the sub-micron ferrous sulfide reagent was at a plating site underlain by glacial till with meltwater channels. Soil mixing was successful for the vadose zone, and not only reduced the Cr(VI), but also immobilized nickel and arsenic. Top-down hydrofracturing allowed the reductant to be spread across the heterogeneous saturated zone, with similar results. A site currently under bench testing is unique due to the sea-like salinity of groundwater. This has indicated excessive dose rates, but further testing shows the reaction kinetics are slowed due to the high salinity. Additional data from laboratory and field testing is anticipated before the conference.