ISCO and ISB Laboratory Treatability Study Case Summary

Summary. Terra Systems, Inc. (TSI) evaluated in situ biological (ISB) treatment and in situ chemical oxidation (ISCO) using soil and groundwater samples from the MW-2 and MW-3 areas of the site. Soil and groundwater at the site are contaminated with volatile organic compounds (VOCs) including 1,1,1-trichloroethane (1TCA), 1,1,2-trichloroethane (2TCA), 1,1-dichloroethene (1DCE), 1,1-dichloroethane (1DCA), 1,2-dichloroethane (2DCA), chloroform (CF), trichloroethene (TCE), cis-1,2-dichloroethene (cDCE), and tetrachloroethene (PCE). Biodegradation products including vinyl chloride (VC), chloroethane (CA), dichloromethane (DCM), chloromethane (CM), ethene, and ethane may be produced under anaerobic conditions. The groundwaters contain barium, chromium, copper, lead, molybdenum, nickel, and vanadium.

ISCO was evaluated using sodium persulfate (Peroxychem's Klozur®) at two dosages (5 and 20 g/L) with sodium hydroxide as the activator to determine the natural oxidant demands and the destruction removal efficiencies in the groundwaters and soils at the site. ISCO using sodium permanganate was also evaluated at dosages of 5 and 20 g/L sodium permanganate to determine the Natural Oxidant Demands (NOD) and the Destruction Removal Efficiencies (DRE) in the groundwaters and soils at the site. ISB treatment was also evaluated using a soluble substrate (sodium lactate), a slow release substrate (TSI's emulsified soybean oil product SRS®), and SRS® in conjunction with a bioaugmentation culture containing *Dehalococcoides mccartyi* (product name TSI-DC). *Dehalococcoides mccartyi* (DHC) is a microorganism known to be able to convert cDCE to vinyl chloride (VC) and ethene. A control treatment with no oxidant or bioremediation substrate was also evaluated.

The laboratory work was done by Erich Hauptmann at TSI in Wilmington, Delaware, under the direction of Michael Lee, Ph.D.

Klozur® loadings of 5 to 20 g/L (0.5 to 2.0%) were evaluated for the MW-2 and MW-3 areas. The sodium hydroxide loadings required to raise and maintain the pH above 10.5 to activate the persulfate ranged from 2,667 mg/L to 8,333 mg/L. Klozur® and sodium hydroxide loadings per cubic yard, assuming a porosity of 25% or 191 L/cubic yard, ranged from 2.1 to 8.4 pounds of Klozur® and from 3.4 to 5.5 pounds of sodium hydroxide. The persulfate natural oxidant demands were relatively low for the six week incubation compared to other sites, ranging from 4.5 to 22.2 pounds per cubic yard. Only the 20 g/L dosage of Klozur® were able to completely eliminate the VOCs in both areas. In the MW-2 area, all of the metals increased relative to control. In the MW-3 area, arsenic and molybdenum increased to a greater extent than the control with persulfate.

Sodium permanganate loadings of 5 to 20 g/L (0.5 to 2.0%) were evaluated or the equivalent of 2.1 to 8.4 pounds per cubic yard. The sodium permanganate natural

oxidant demands were equivalent to 3.0 and 7.4 pounds per cubic yard, which are relatively low compared to many soils. Both dosages of sodium permanganate were able to treat all of the VOCs to below the detection limits in both sites. However, arsenic, chromium, and lead increased to a greater extent in the 20 g/L permanganate treatments than the control.

In situ bioremediation with lactate and with TSI's emulsified vegetable oil product, SRS®, resulted in the partial transformation of PCE and TCE to cis-1,2-DCE and loss of 1,1-DCE in both areas. Almost complete transformation of PCE, TCE, cDCE, and 1DCE was observed in the bioaugmentation treatments from both areas with SRS® and TSI-DC with the production of ethene. Substrate injection and bioaugmentation with a dechlorinating enrichment containing D*ehalococcoides mccartyi* would be required if ISB is chosen. Concentrations of antimony, arsenic, barium, chromium, cobalt, copper, lead, molybdenum, nickel, vanadium, and zinc increased in groundwater phase of the SRS® and SRS® + TSI-DC treatments relative to the controls.

For a copy of the full 10-page report please contact Michael D. Lee, Ph.D., Vice President Research and Development at 302-798-9553 or email him at mlee@terrasystems.net. Alternatively you can submit your request using the form on the *Contact Page* of our website.