

Combination of Chemical Oxidation and Electrokinetic for LNAPL Remediation in a Tropical Soil Capillary Fringe

Lilian Puerta Machado Silveira (lpms.consultoria@gmail.com), Bruna Oliveira Agostinho, Isabela Pinheiro Leme, Letícia Mina Umiji Morioka, Sergio Rodrigues Honda, Sheila Aparecida Correia Furquim, and Juliana Gardenalli Freitas (jugardenalli@gmail.com)
(UNIFESP, Diadema/SP, Brazil)

Background/Objectives. In situ chemical oxidation (ISCO) is a well-established technology for site remediation, however, in many cases, a combination of technologies is necessary to achieve the remediation goals. One technique that can be combined with ISCO is the electrokinetic (EK) method, in which an electric potential difference is applied in a porous medium, promoting the processes of electromigration, electroosmosis, transport of electrically charged particles by electrophoresis, oxidation and reduction reactions. These processes can aid in the oxidant transport through soils and promote contact between the oxidant and contaminant, which is one of the challenges for remediation success. Both the contact and the transport are particularly difficult in clayey soils, as some found in the tropical regions, and in the capillary fringe, where LNAPLs accumulate. In this study, we evaluated the potential for the association of ISCO with EK for the remediation of LNAPL in the capillary fringe of a tropical Brazilian soil.

Approach/Activities. The study was developed in the Universidade Federal de São Paulo (UNIFESP), where two tests were performed to evaluate the transport of persulfate and toluene degradation, being: 1) ISCO, and; 2) ISCO + EK. A 0.8m long and 0.6m height two-dimensional physical model with 165 sampling points was filled with a 67.5% clay soil from the Oxisol order. Flow was established by fixing a constant hydraulic gradient. The water used had an electrical conductivity (EC) of $400 \mu\text{S cm}^{-1}$, prepared with DI water and potassium chloride. The LNAPL contamination was simulated by releasing a 2% toluene and 98% heptane mixture. In both tests, potassium persulfate (14 g L^{-1}) was continuously injected through a well in the saturated zone. In Test 2, direct current was applied with a 30V power source through graphite electrodes. Water samples were analyzed for pH, EC, toluene by gas chromatography and persulfate by spectrophotometry. Soil samples were collected after the tests for organic matter (OM) determination.

Results/Lessons Learned. Comparison of the two tests showed that both methods promoted toluene degradation. When only ISCO was applied, the oxidant that reached the contaminant region was consumed within the source area and had lesser impact in the downgradient contamination. With the application of ISCO+EK, since the source was positioned within the electric field, the entire persulfate mass was directed upwards into this region within the capillary fringe due to electromigration, and persulfate concentration reached values 5 times higher than that injected, promoting more significant impact downgradient the source zone. Persulfate activation likely occurred in both tests. In Test 1, with ISCO alone, activation could occur due to the presence of naturally occurring iron in the soil. In Test 2, ISCO + EK, alkaline activation possibly occurred due to the pH rise near the cathode (up to 14); and, in the anode region, activation may have occurred due to the higher Fe^{2+} availability due to the low pH (1.5). In the two tests a reduction of OM was observed. However, this reduction was greater in the ISCO + EK test, with OM being absent throughout the electric field region, which could contribute to the desorption of the contaminants, improving the contact of the contaminant with the oxidant.