Dose-Response Curves Compare the Effectiveness of Combined Cement-Persulfate Treatment with Standalone ISS and ISCO in Ten Different Soils

Daniel P. Cassidy (daniel.cassidy@wmich.edu)
(Western Michigan University, Kalamazoo, MI, USA)
Vipul J. Srivastava (vipul.srivastava123@gmail.com)
(EcoLogic & Sustainable Strategies, Inc.)

Background/Objectives. Laboratory studies were done on 10 different soils contaminated with petroleum hydrocarbons to compare the effectiveness of combining in situ chemical oxidation (ISCO) with in situ stabilization/solidification (ISS) with ISS and ISCO as standalone treatments. The overall goal of the study was to quantify the treatment achieved with alkaline (NaOH)-activated persulfate (ISCO) and cement-based ISS with a combined ISCO/ISS strategy using cement to achieve alkaline persulfate activation. The performance of ISCO was quantified by measuring the destruction of contaminants achieved, and the performance of ISS was quantified by measuring the reduction in contaminant leachability achieved for each dose of persulfate and cement. The specific objectives were to determine whether; (1) Portland cement and other common ISS amendments can activate persulfate to achieve ISCO in a short time period (hours to days), (2) cement activation of persulfate achieves contaminant destruction similar to activation with NaOH, (3) persulfate activation and related chemical oxidation reactions negatively impact ISS performance parameters, and (4) combined ISCO/ISS can result in enhanced overall performance, vis-à-vis contaminant destruction and leachability.

Approach/Activities. The 10 test soils were from either manufactured gas plant (MGP) sites or petroleum refinery/storage facilities. The contaminants included polycyclic aromatic hydrocarbons (PAH) (including naphthalene, the most soluble PAH), total petroleum hydrocarbons (TPH), and benzene, toluene, ethylbenzene, and xylenes (BTEX). Contaminant concentrations were measured using standard methods, to determine the chemical oxidation of contaminants achieved with activated persulfate. The ISS amendments tested included Portland cement and other common ISS amendments. The pH and temperature were monitored as indirect indicators of conditions favorable for persulfate activation, and the degree of activation was verified with measurements of persulfate concentrations in filtrate samples. Synthetic Precipitation Leaching Procedure (SPLP) was used to quantify the reduction in contaminant leachability achieved with ISS. Hydraulic conductivity (K) and unconfined compressive strength (UCS) were also measured as other common ISS performance parameters. Doses of $Na_2S_2O_8$ ranged from 0.25% to 5% (by weight), and cement doses ranged from 0.5% to 10% (by weight).

Results/Lessons Learned. Chemical oxidation removed a significant portion of the contaminants of concern (COCs), including BTEX, naphthalene, and higher molecular weight petroleum hydrocarbons. Contaminant destruction showed saturation-type dose-response curves, with pronounced contaminant removal at low $Na_2S_2O_8$ doses and decreasing removal with higher doses. Plots of reduced COC leachability versus cement dose for combined oxidation and stabilization treatments were similar to those for COC oxidation, but for stabilization treatments the dose-response was roughly linear, and inversely related to the molecular weight of the COCs. Even with low $Na_2S_2O_8$ doses (1.5% and lower), combined oxidation and stabilization treatments reduced COC leachability far more than stabilization treatments alone using the same PC dose, because of the COC removal achieved by $Na_2S_2O_8$ oxidation. The increase in soil strength and decrease in hydraulic conductivity achieved with ISS were unaffected by $Na_2S_2O_8$.