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Reduction of Cr(VI) to Cr(III) in Artificially-Contaminated Soil using Chemical Reagents

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The presence of hexavalent chromium (CrVI) in soil is an environmental concern due to its effect on human health. The concern arises from the leaching and the seepage of Cr(VI) from soil to groundwater. A remediation approach that has been studied in the literature is that of reducing the hexavalent chromium to its trivalent form using a chemical reagent, namely ferrous sulfate heptahydrate (FeSO4.7H20). In this study, we compared performance of ferrous sulfate heptahydrate to sodium thiosulfate (Na2S2O3), a less costly reductant. The means of measuring the performance of the reductants is the US EPA's Toxicity Characteristic Leaching Procedure (TCLP), which states that the total chromium release from the soil must be less than 5 ppm. Because this treatment approach is pH sensitive and thus, susceptible to acid rain effects, it was studied with the intention that it be coupled with a stabilization/fixation approach so as to provide a second level of treatment; i.e. it is not intended to be the stand-alone treatment approach.

In this study, the reductants were initially used to treat a contaminated, artificial soil and allowed to cure for varying time periods to determine the minimum curing time. Contaminated artificial soil were then prepared using the same percentage of white sand, kaolinite clay and potassium chromate and varying amount of water as a function of the humidity of the specimens in order to illucidate the effect of moisture on the reductant performance. Finally, the reductant (either ferrous sulfate heptahydrate or sodium thiosulfate) was added in varying doses to determine the best ratio Cr/reagent dose. Chromium release from the soil was evaluated with a modified Toxicity Characteristic Leaching Procedure (TCLP) test after allowing the samples to cure.

Results indicated that chromium(VI) released from the specimens was less than 5 ppm for the samples treated with either ferrous sulfate heptahydrate (99.9% of reduction) and sodium thiosulfate (98.7% of reduction) with ratio Cr/reagent equal to 18.7 in both cases. In addition, samples treated with ferrous sulfate also exhibited a binding effect. In summary, reduction to a lower valence state can be an effective treatment option when coupled with a stabilization/solidification treatment, so that any chromium subsequently leached from the treated soil into groundwater is the less toxic and less mobile trivalent form of chromium. An alternative to ferrous sulfate heptahydrate, the less-expensive sodium thiosulfate, performed well as a reductant and is suggested for further study.