Treating Cr(VI) Contaminated Soil by Solidification/Stabilization

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Abstract

In this study a combination of reduction and cement-based solidification/stabilization (S/S) was used in treating hexavalent chromium contaminated soil. Preliminary studies showed that Cr(VI) was difficult to immobilize by cement only and leachate exceeded the TCLP limit. Pretreating the soil with ferrous chloride ($FeCl_2$) substantially reduced the leaching of Cr(VI) to an efficiency of 95%. TCLP results showed that the leaching of Cr(VI) and total chromium (Total Cr) was reduced with Fe(II) treated soils. Chromium oxide (Cr_2O_3) was identified as a reaction product by X-ray diffractometry (XRD) analyses. The Fe(II) pretreatment enhanced the S/S treatment efficiency of Cr(VI).

1. Introduction

The widespread use of chromium has resulted in the contamination of soils and waters. Cr(VI) contamination is of great concern because of its acutely toxic, mutagenic, carcinogenic and leaching potential. Solidification/stabilization (S/S) is one of the remediation technologies that have been developed and applied for treating inorganic hazardous waste. This study was to evaluate the potential of using cement-based S/S for treating K_2CrO_4 contaminated clayey soil.

2. Testing program

Contaminated Soil. The contaminated soil was prepared by adding potassium chromate (K_2CrO_4) into the soil to a concentration of 25,000 mg/kg. The control clayey soil was prepared by mixing sand (79%), kaolinite clay (20%) and organic matter (1%).

Reducing Agent. The reduction of Cr(VI) was achieved by mixing ferrous chloride ($FeCl_2$) up to 10% (by weight of soil) to Cr(VI) contaminated soil.

Stabilization/Solidification (S/S). Portland cement (Type I) was used as the binder for S/S treatment. The cement-to-soil ratio and water-to-cement ratio were 0.2 and 0.5 (by weight), respectively. Unconfined compressive strength (UCS) and Toxicity Characteristic Leaching Procedure (TCLP) test were conducted on solidified binders after 28 days of curing.

Chromium Measurement. The measurement of Cr(VI) and total chromium (Total Cr) were followed AWWA Standard Method 312B.

XRD Study. A Siemen's D5000 X-ray diffractometer which had a copper tube operated at 50 kV and 40 mA was used for the XRD characterization for reflection angle (2) in the range 10 to 50o.

3. Results

Leaching of Chromium. The leaching of Cr(VI) and Total Cr from untreated contaminated soil was 1,000 and 1,020 mg/L, respectively. When the soil (S) was treated with cement at a C/S ratio of 0.2, the maximum amount of Cr(VI) and Total Cr leached out were 675 and 682 mg/L, respectively. All failed to meet TCLP limit of 5 mg/L.

Reduction of Cr(VI). Addition of $FeCl_2$ reduced the leaching of Cr(VI) according to the following reaction:

(1)

The reduction of Cr(VI) by Fe(II) salt resulted in reducing the soil's pH from 6.1 to 5.9, 2.0 and 1.6 for 1%, 4% and 10% Fe(II) addition.

S/S Treatment. The technique of coupling Cr(VI) reduction by $FeCl_2$ and S/S treatment reduced the leaching of Cr(VI) and Total Cr more effectively. The efficiencies in reducing leaching of Cr(VI) and Total Cr from Cem/1%$FeCl_2$+CrSoil were 55 and 40%, respectively. The efficiencies increased to 96 and 45% for Cem/4%$FeCl_2$+CrSoil system. They were further improved to 99% and 50% for Cem/10%$FeCl_2$+CrSoil system. The transformation of Cr_2O_3 to $Cr(OH)_3$ in cement hydration condition ($pH>12$) explained the higher efficiency of this technique. All samples had UCS greater than the EPA requirement of 0.34 MPa (50 psi).

XRD Studies. Potassium chromate was identified at 2 of 29.8o, 30.1o, 34.5o and 35o. When the soil was treated with Fe(II), reaction product Cr_2O_3 was identified. A formation product $Cr(OH)_3$ was identified when the sample was further treated with cement.

4. Conclusions

1) Cement-based S/S did not fix Cr(VI) contaminated soil to below TCLP limit 5 mg/L.
2) Adding $FeCl_2$ reduced Cr(VI) to Cr(III) and caused soil's pH reduction.
3) A process coupling Cr(VI) reduction and cement-based S/S treat Cr(VI) contaminated soil efficiently.

5. References

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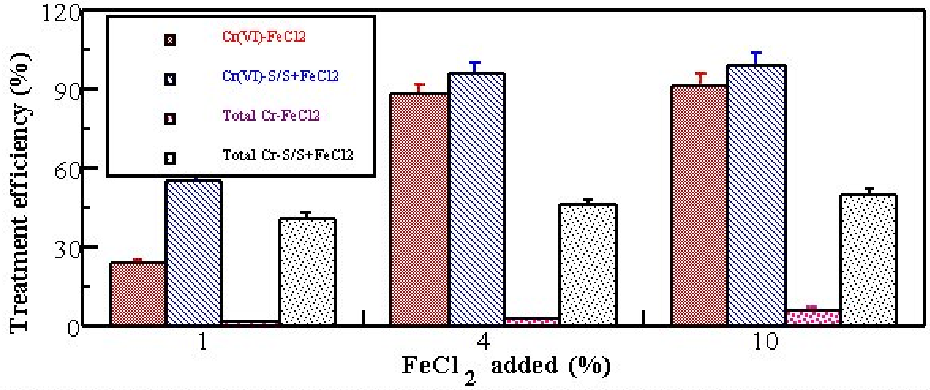

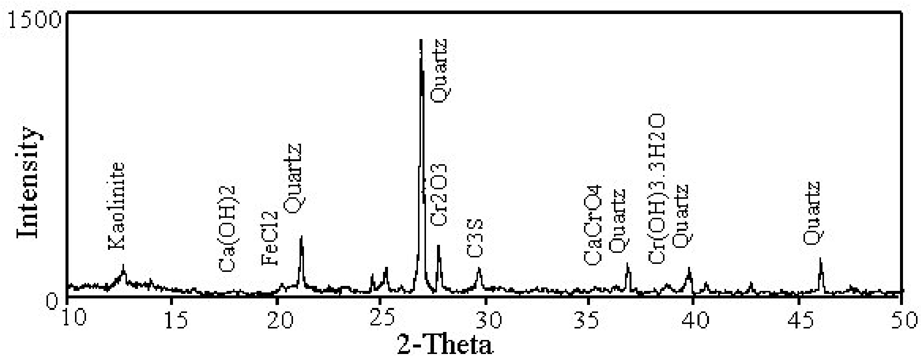

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