Multi-scale Evaluation of the Solidification/Stabilization Technology for the Remediation of Zinc/Chlorine-Contaminated Soil

*Yasong FENG[1], Yanjun DU[1], Weiyi XIA[1], Mingli WEI[1], Haoliang WU[1], Weiwei REN[1]

1. Jiangsu Key Laboratory of Urban Underground Engineering & Environmental Safety, Institute of Geotechnical Engineering, Southeast University.

Solidification/Stabilization methods are routinely used in the remediation of contaminated land. Laboratory scale environmental remediation of contaminated land and groundwater has previously been studied by many researchers. However, there are not any studies on larger scale experiments involving applications in the field. Moreover, the immobilization mechanisms of pollutants are not described in multi-scale to give more detailed interpretation.
This study presents a systematically multi-scale investigation of the immobilization effects of two binders (GM and KMP) on zinc and chlorine contaminated soil from an abandoned galvanizing mill in Jiangsu province, China. The physical-chemical properties including dry density, soil pH, dynamic cone penetrometer, unconfined compression strength and toxicity leaching properties were tested on the treated soil at 1-28 days of curing after in-situ application of solidification and stabilization. Furthermore, laboratory tests, such as the modified BCR sequential extraction procedure, X-ray diffraction, scanning electron microscope and energy dispersive spectroscopy tests, were also conducted to investigate the immobilization mechanism of Zn or/and Cl in both the GM and KMP binders treated soils.
The results demonstrate that the dry density of stabilized soil has a significant increase of 10.68%-12.21% after 28 days of curing. Corresponding with the dry density, the strength of stabilized soil is about 5-7 times higher than that of the untreated soil treated after 28 days of curing. With the addition of binders, the pH of treated soils increases to 6.75-6.96 from 4.23 after 28 days of curing. Moreover, the two binders have different immobilization effects on zinc and chlorine in the contaminants soils, as KMP is better on immobiling zinc, while GM has a stronger ability on immobilization of chlorine.
In addition, the production of $Zn_3(PO_4)_2$, $Zn(OH)_2$, $CaZn_2(PO_4)_2$, $CaZn_2(OH)_6{\cdot}2H_2O$, $Mg_2Cl(OH)_3{\cdot}4H_2O$, $CaCl(OH)$, $Ca_5(PO_4)_3Cl$ and $Zn_5(OH)_8Cl_2$ are the most probable mechanisms in the KMP tread soil contaminated with Zn and Cl. However, in the GM tread soil, the production of $Zn(OH)_2$, $Ca(CO_3)_2(OH)_{17}Cl$, $Mg_2(OH)_3Cl{\cdot}4H_2O$, $CaCl(OH)$ and $Ca_8ZnSi_4O_{16}Cl_2$ are the most probable immobilization mechanisms for Zn and Cl. Furthermore, these results are interpreted based on the changes in chemical speciation of Zn and/or Cl in the treated soils.
Overall, this study demonstrates that the zinc and chlorine in soil can be effectively stabilized by both the two binders, and the leached toxicity of treated soil can meet the requirements for soil remediation. The outcomes of this research are significant from engineering, environmental and economic perspectives.

Keywords: zinc and chlorine contaminated soil, solidification/stabilization, bearing capacity, toxicity characteristic leaching characteristics, soil pH, immobilization mechanism

