

ABSTRACT

Development of Cost-Effective Treatments for Lead-Acid Battery Waste and Lead-Contaminated Soils in Trinidad

Azeena Ali

Lead is possibly the most prevalent toxin in Trinidad to which the local population is exposed, with its main source being spent lead (Pb)-acid batteries. During the recycling and repairing of Pb-acid batteries locally, approximately 60% of the waste produced is the battery paste. The battery paste poses the greatest threat to the environment because of its high levels of Pb (66%) and its particulate nature hence, its treatment was undertaken as a priority. In addition, four sites in East Trinidad were investigated for possible remediation, since they were heavily populated, agricultural, and wetland areas.

Cement-based solidification/stabilization (S/S) technology was used in the treatment of the battery paste and contaminated soils, with its primary binding agent being either ordinary Portland cement (OPC) or sulphate resisting Portland cement (SRPC). Immobilization of lead was achieved by its cementation into a concrete specimen, with additions of various admixtures at varying waste/cement ratios, water/cement ratios and curing times. Each concrete specimen in the treatment process was evaluated with respect to its leachability using a modified US Environmental Protection Agency Toxicity Characteristic Leaching Procedure (US EPA TCLP) and a modified American Nuclear Society (ANS) 16.1 leachability test for crushed and monolith specimens respectively. The TCLP results indicated that

OPC treatment of contaminated soils satisfied the US EPA TCLP criteria ($\text{Pb} < 5.0 \mu\text{g/mL}$) at the recommended 28-day curing period, but that the battery paste failed. However, satisfactory results were obtained for treatments with OPC-admixtures and SRPC. The ANS 16.1 criterion was also satisfied for all treated waste with leachability indices > 6 , demonstrating the effectiveness of OPC as a binder in the treatment process.

The compressive strengths of the monolithic specimens from all the mix designs were greater than the required 0.345 MPa (50 psi), but the specimens showed relatively high levels of leachable lead with both the TCLP and ANS 16.1 test procedures. As a result, the monoliths were encapsulated with an asphaltic emulsion which reduced the levels of leachable lead to less than $0.1 \mu\text{g/mL}$. The immobilization mechanisms of Pb in the cemented wastes were deciphered using X-ray diffraction spectrophotometry and sequential speciation. Lead was found to be physically entrapped within the hydrated silicate matrix as well as precipitated as oxides, sulphates, carbonates, hydroxy carbonates and silicate in the cementitious matrix. Overall, exploitation of these cost-effective treatment options ($\approx$ \$80 US per tonne of waste) will drastically reduce the contamination of waterways and metal-contaminated sites, thus rendering them safe.

Keywords: lead-contaminated waste; solidification/stabilization; admixtures; asphaltic emulsion; US EPA TCLP, ANS 16.1; compressive strength; X-ray diffraction spectrometry; sequential speciation.