Impact Factor (SJIF): 3.632

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 3, Issue 5, May-2016

Immobilization of heavy metals of Hazardous waste using different binding materials

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Abstract* — Solidification/Stabilization (S/S) is a chemical treatment process which aims to either bind or complex the compounds of a hazardous waste stream into a stable insoluble form or to entrap the waste within a solid matrix. The U.S. Environmental Protection Agency (EPA) has identified S/S as the best demonstrated available technology for 57 RCRA (Resource Conservation and Recovery Act)-listed hazardous wastes. The present study deals with the solidification/stabilization of waste sludge generated from metal pickling operation of an electroplating industry to prevent or minimize the release of the contaminant into the environment. After chemical characterization of sample, the solidification/stabilization was performed using different binding material like cement, lime and sand in different combination. Efficiency of different combination to immobilize heavy metals of waste sludge after 14 and 28 days solidification/stabilization assessed by leaching test and further analyses.

Keywords-component; Heavy metals, Solidification/Stabilization, TCLP

INTRODUCTION

Due to rapid industrialization, the total volume of hazardous industrial waste increases significantly. Therefore, appropriate management is required in order to reduce its adverse impact on human population and ecosystems. Secure landfilling of hazardous waste is a common waste management practice and one of the cheapest methods for organized waste management in many parts of the world. Landfilling pose serious threat to the quality of the environment if it is incorrectly secured and improperly operated. The threat to surface and ground waters could be deleterious. Recycling of all industrial wastes is not feasible and with the increasing contamination of the natural environment, the problem of heavy metal mobilization becomes more and more significant. Various technologies have been developed to convert hazardous waste into non-toxic form or to reduce the potential release of the toxic compounds into the environment. In order to reduce the scale of pollution of waste at landfill sites, solidification and stabilization (S/S) techniques are used to prevent or minimize the release of hazardous compounds from contaminated waste into the environment by producing a solid mixture. Stabilization may be described as a process by which contaminants are fully or partially bound by the addition of supporting media, binders, or other modifiers. Likewise, solidification is a process employing additives by which the physical nature of the waste (as measured by the engineering properties of strength, compressibility, and/or permeability) is altered during the process. Thus, stabilization and solidification would encompass both reduction in waste toxicity and mobility as well as an improvement in the engineering properties of the stabilized material. During stabilization, certain contaminants may be destroyed and organics may disappear as a result of volatilization. However, the stabilization of inorganic contaminants that are already in their atomic form, such as cadmium, lead, and other metals, is more practicable. Binding agents like cement, lime, pozzolan etc. are used to stabilize the waste and turning it into a monolithic solid with some structural integrity. Cement is widely used in stabilization techniques due to its low cost; in addition, the high pH value of the hydrated Portland cement renders many metal contaminants insoluble as a result of the precipitation of their less soluble hydroxides. The potential for contaminants loss from a stabilized mass is usually determined by leaching tests. Leaching is the process by which contaminants are transferred from a stabilized matrix to a liquid medium such as water.

I. MATERIALS AND METHODS

A. Materials

Material under study was sludge originated in the pickling operation of an electroplating industry and falls under category 12 of schedule-I of Hazardous Material (Management, Handling and Transboundary Movement) rules 2008. Cement, Sand and Lime were used in different combination for stabilization/solidification process.

TABLE 1: DIFFERENT COMBINATIONS

Sample no.	Waste sludge (%)	Cement (%)	Sand (%)	Lime (%)
S1	50	20	20	10
S2	60	20	10	10
S3	60	40	-	-
S4	70	30	-	-

B. Stabilization/Solidification Method

Waste sample was first dried at room temperature for one day and then crushed or grinded and sieved to get uniform waste concentration. After that it was mixed with different uniform binding agents like Cement, Lime and Sand in different proportion that are given in below table. Water was then added to the mixture to create a sludgy mixture (50 g of the mixture with 25 ml of water). Consequently, the mixture was stirred for 10 minutes and placed to plastic forms to solidify. Solidification period was set to 14days and 28 days under laboratory temperature. In below table % of every element is in terms of total weight of final sample. Weight of final sample for every combination is taken as 450gm. casting of all cubes at a time of size 7cm X 7cm X 7cm were carried out using a mold made of marble with inner plastic coating.

FIGURE 1: SAMPLE S1, S2, S3 AND S4

II. PREPARATION OF LEACHATE AND ANALYSIS

From the pickling sludge and stabilization agents, parallel samples of water leachate according to USEPA 1311-Toxicity Characteristics Leaching Procedure (TCLP) were prepared for each combination. Ratio of solid and liquid phase was 1:20; for the preparation, demineralized water was used. After 18 hours of shaking with shaker, solid phase was separated by vacuum filtration using membrane filter with 0.6 to 0.8μm pore size. Chemical composition of the studied samples was determined using Atomic Absorption Spectrophotometer (AA201). The total content of selected elements in solid samples (Cu, Cd, Pb, Cr, Ni and Zn)—after total acid decomposition of the solid sample in a mixture HNO_3 +H_2SO_4 + Water —were determined by AAS.

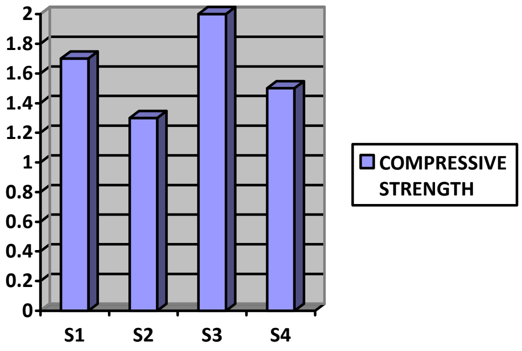
TABLE 2: CONTENT OF OBSERVED PARAMETERS IN THE SOLID PHASE

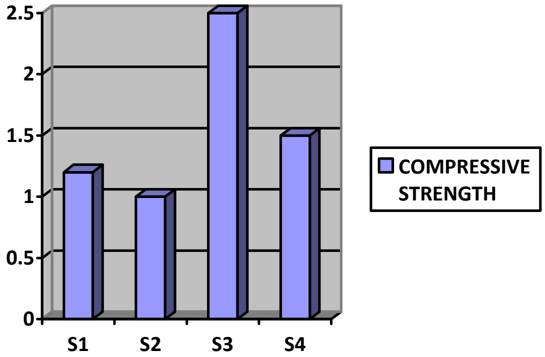
SR.NO.	PARAMETERS	RESULTS	UNIT
1	pH	8.1	-
2	Moisture	30.7	%
3	Cu (Copper)	5	mg/kg
4	Fe (Iron)	BDL	mg/kg
5	Zn (Zinc)	BDL	mg/kg
6	Cd (Cadmium)	1	mg/kg
7	Pb (Lead)	110.6	mg/kg
8	Ni (Nickel)	16.5	mg/kg
9	Mn (Manganese)	BDL	mg/kg
10	Cr^{+6} (Hexavalent Chromium)	79.6	mg/kg

11	Arsenic (As)	BDL	mg/kg

III. COMPRESSIVE STRENGTH STUDY

Compressive strength for all the combinations was found to be well above the required strength for landfill. Presence of cement seems to govern the strength to the solidified matrix. Compressive strength of the solidified matrix of the combination S3 for 28 days was reported maximum compressive strength from all combinations.





IV. CONCLUSION

From research it is concluded that Compared with other remediation technologies, S/S always have many advantages like relatively low cost of binding material and ease of use and processing, From different combination S3 (40%cement + 60% waste) was having maximum compressive strength when compared with other combinations. TCLP process is still remaining to perform for all combinations. From above study it is clear that cement is best solidification agent from all materials and consistent from source to source that eliminate some of the variables in designing the S/S process, Good long-term stability both physical and chemical, Good impact and comprehensive strength, High resistance to biodegradation, and Relatively low water permeability.

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