IMMOBILIZATION OF HEAVY METALS USING SOLIDIFICATION/STABILIZATION TREATMENT: A REVIEW

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ABSTRACT

Leaching of heavy metals is a huge problem for industries generated hazardous waste containing high amount of heavy metals and recovery of metals from waste is not feasible all the time so various technologies have been developed to convert hazardous waste into non-toxic form. Stabilization and solidification is one of the techniques used to convert hazardous waste into stabilized product. Stabilization and solidification are physicochemical processes widely used in management of hazardous waste. The terms solidification/stabilization and stabilization/solidification are often used interchangeably and are referred to as S/S. Both techniques are incorporated as one treatment method for immobilization of waste containing high amount of heavy metals using different binding material. Solidification/Stabilization iimproves the handling and physical characteristics of the waste and decrease the surface area across which transfer or loss of contaminants can occur. Binding materials like portland cement, geopolymers, lime, sand, clay, fly ash etc. are used in different research work until now. Thus, information obtained from different research papers this paper shows that cement based solidification is best suited for immobilization of metals like Cu, Zn, Fe, Cd, Ni etc. it also gives good strength to final solidified matrix. Toxicity characteristic leaching procedure (TCLP) is probably the best method as far as leaching is concerned and 28 days is standard time period provided for hydration.

Keyword: - *Solidification and Stabilization, TCLP, Leachability, Heavy metals*

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1. INTRODUCTION

Rapid industrialization is creating lot of problems in present scenario; the total volume of hazardous waste increases significantly which can adversely affect our environment and human health. Therefore, appropriate management is required. Due to limited sites, cost, technology and strict environmental standards for landfilling, waste disposal has become a major concern in most of the industries of India. 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. Stabilization and Solidification have been widely applied in the management of hazardous wastes. The technologies are being applied to (1) the treatment of industrial waste, (2) the treatment of wastes prior to secure landfill disposal, and (3) the treatment of contaminated land where large quantities of soil containing contaminants are encountered. In general terms, stabilization is a process where additives are mixed with waste to minimize the rate of contaminant migration from the waste and to reduce the toxicity of the waste .Thus, stabilization may be described as 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, objectives of stabilization and solidification would encompass both the reduction in waste toxicity and mobility as well as an improvement in the engineering properties of the stabilized material. 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.

2. SOLIDIFICATION/STABILIZATION PROCESS

Stabilization is a process employing additives (reagents) to reduce the hazardous nature of a waste by converting the waste and its hazardous constituents into a form that minimizes the rate of contaminant migrating into the environment, or reduces the level of toxicity. Fixation is often used synonymously with stabilization. Stabilization is accomplished through the addition of reagents that

- Improve the handling and physical characteristics of the waste
- Decrease the surface area across which transfer or loss of contaminants can occur
- Limit the solubility of any pollutants contained in the waste
- Reduce the toxicity of the contaminants

In contrast, solidification is described as a process by which sufficient quantities of solidifying material, including solids, are added to the hazardous materials to result in a solidified mass of material. Solidifying the mass is accomplished through the addition of reagents that increase the strength, decrease the compressibility, and decrease the permeability of the waste.

In most cases, the processes of stabilization and solidification are combined in the treatment of hazardous wastes. The potential for contaminant 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.

During stabilization, certain contaminants may be destroyed by, for example, the dechlorination of chlorinated hydrocarbons. Other organic may "disappear" as a result of volatilization. However, the stabilization of inorganic contaminants that are already in their atomic form, such as cadmium, lead, zinc, and other metals, should mimic nature. By studying the form in which they occur in nature, one can learn much about the optimum stabilization method.

2.1 Solidification/stabilization mechanisms

In S/S processes, immobilization of contaminants, depending on their nature, occurs by three main mechanisms:

1. Chemical fixation of contaminants by interactions between the hydration products of binding material and the contaminants,
2. Physical adsorption of contaminants on the surface of binding products, or
3. Physical encapsulation of contaminated waste or soil.

2.2 List of binders used for S/S process

INORGANIC BINDER SYSTEM	ORGANIC BINDER SYSTEM
Portland cement	Bitumen
Portland slag cement	Urea formaldehyde
Portland pozzolan cement	Polybutadiene
Portland cement-silicate system	Polyester
Polymer modified cement	Epoxy
Masonary cement	Polyethylene
Lime-pozzolan cement	
Calcium aluminate cement	
Alkali-activated slag cement	
Alkali-activated pozzolan cement	
Phosphates	
Gypsum	
Sulfur polymer cement	
Alkali silicate minerals	

3. REVIEW OF LITERATURE

TYPE OF WASTE	METALS CONCERN	BINDING MATERIAL USED	HYDRATION PERIOD	SIZE OF SOLIDI-FIED MATRIX	LEACHING PROCEDURE USED	METHOD USED TO MEASURE COMPRES-SIVE	FINDINGS

						STRENGTH	
Fly ash	Cd, Cu, Cr, Zn and Ni	cement GEOROC DOROSOL C50	1, 4, 7 and 28 days	-	USEPA TCLP[19]	-	For the immobilization of Zn, the solidification period of 28 days is satisfactory. However, for the immobilization of Cd, the amount of cement (20%, 30%) and the solidification period (1–28 days) is important.
Electric arc furnace (EAF) dust	Pb, Cd, Cr and Zn	Geo-polymers	7 and 28 days	30mm dia-meter and 41mm height	USEPA TCLP[19], UNE-EN 12457[20] and NEN 7341[21]	ASTM D-1633-84	Cr and Zn were well immobilized in all mixtures, leached fraction of Pb and Cd is high and OPC and Lime leads to poor resistance compare to geopoly-mers.
Sludge from steel plating industry	Fe, Ni, Cr, Zn, Cu and Mn	Portland cement	3 days to 112 days	25.4mm X 25.4mm X 25.4mm	USEPA TCLP[19]	-	20:80 ratio of cement and solid waste showed minimum leaching of all heavy metals well below the USEPA's limit after 112 days of curing using TCLP analysis.
Sludge from electro-plating	Zn, Cr and Pb	Cement, Sand, Clay, Fly ash and	28 days	40mm X 40mm X 40mm	USEPA TCLP[19]	ASTM C-109-86	Zinc shows higher leaching potential and

industry		Lime					compressive strength found maximum in case of cement mortar lime system.
Decom-posed solid waste	Fe, Cu and Ni	Ordinary Portland cement (OPC)	3,7,14,21 and 28 days	5cm X 5cm X 5cm	American nuclear society (ANS) 16.1	ASTM C-109-93	30% waste as substitution of total volume of the fine aggregate having mix proportion 1:3 (OPC : Fine aggregates) was optimum mixing composition for paving block and that satisfied the minimum compressive strength requirement of Bangladesh.

4. CONCLUSIONS

From research it is concluded that Compared with other remediation technologies, cement-based S/S always have many advantages like relatively low cost and ease of use and processing, Composition of Portland cement is 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. USEPA TCLP[19] is also accounted as a best leaching procedure that is used for leachate generation compared to other procedure while solidification/stabilization process is concern.

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