A Review: Solidification/Stabilization of Hazardous Waste

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Abstract— Now a days human beings are very popular in technology & science but seem to be very helpless as for as its controlling the decay and preservative their own environmental issues. For save the environment conservation and preservation have taken on very importance in the world in recent years. Deep changes are taking place in our ways of living and working also. Among these variations resource conservation and recycling of hazardous waste have become one of the principle problems. The stabilization/solidification (S/S) technique of a hazardous (hospital) waste incineration (HWI) fly ash containing hazardous metals e.g. Pb, Cd, Cr, Zn. Different substances e.g. sodium hydroxide, potassium hydroxide, sodium silicate, potassium silicate as well as ground blast furnace slag have been used. To this end, the effects of curative conditions and composition have been tested. S/S solids are submitted to shear strength and leaching tests to evaluate the results obtained and to evaluate the efficiency of the treatment. Concentrations of the metals leached from S/S produces were strongly pH dependent, show that the leachate pH was the most vital variable for the control of metals.

Key words: Hazardous Waste, pH

I. Introduction

In India, the rate of generation of hospital wastes is assessed to be 1.69 to 2.3 kg/day/bed and out of which 15-17% is found to be bio-medical waste. If this 15-17% hazardous waste is mixed with the entire waste then 100% waste will become harmful. This is a huge amount therefore; it required to a proper management and treatment. Incineration is a treatment process, which reduce the amount of hazardous waste. But million tons of incineration ash as by-product also contributes to environmental pollution so it also required a proper and effective disposal.

Solidification/stabilization (S/S) is a well-established remediation technology for treatment of contaminated soil, sediment, sludge, and waste (i.e., contaminated material). S/S is a process of blending treatment reagents1 into contaminated material to impart physical and/or chemical changes that result in reduced environmental impact of the contaminated material to groundwater and/or surface water. Section 2 of this document provides an overview of S/S technology. S/S is one of the most common in situ technologies used at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites for source control and was the second most commonly used in situ source treatment control in fiscal years 2005–2008 (EPA 2010d).

S/S treatment is used to treat contaminated media throughout remediation of contaminated properties. The authorizing necessities for hazardous waste management facilities under RCRA include requirements for owners of these facilities to remediate formerly contaminated zones at the facility. S/S is the treatment technology for regulatory the sources of environmental contamination at Superfund program remediation sites. 25% of selected remedies for these sites include the use of S/S technique.

II. Technology Description

S/S is a remediation technology used to treat contaminated material. Typically, S/S includes processes that mix inorganic cementitious/pozzolanic reagents into contaminated material to transform it into a durable, solid, low–hydraulic conductivity material that reduces the rate of contaminant migration through leaching. Although solidification and stabilization are defined separately, they are often implemented simultaneously through a single treatment process. EPA defines each as follows (EPA 2000):

Solidification involves the processes that encapsulate contaminated material to form a solid material and restricts contaminant migration by decreasing the surface area exposed to leaching and/or by coating the contaminated material with low-permeability materials. Solidification can be accomplished by mechanical processes that mix the material and one or more reagents. Solidification entraps the contaminated material within a granular or monolithic matrix.

Stabilization involves the processes where chemical reactions occur between the reagents and contaminated material to reduce the leachability of contaminated material into a stable insoluble form. Stabilization chemically binds free liquids and immobilizes contaminated materials or reduces their solubility through a chemical reaction. The physical nature of the contaminated.

III. General S/S Process

The S/S process involves the incorporation of reagents, additives, and water with contaminated media to produce a material with improved physical and chemical properties. The overall process commonly includes

1) the establishment of material performance specifications based on remediation goals,
2) treatability studies intended to develop an appropriate mix design of reagents and additives which addresses material performance specifications and refines implementation techniques and construction performance specifications,
3) mobilization of field equipment and implementation of the S/S mix design on a field scale, and
4) monitoring of material performance after the remediation process is completed.

IV. Solidification/Stabilization Technology Overview

This section presents a brief overview of S/S. In-depth information on S/S can be found in the literature cited in this document and elsewhere. Several useful references on the technology include Conner (1990 and 1997), the United Kingdom Environment Agency2 (2004a, 2004b), EPA (1986, 1989, 1999a, 2009b, 2010d), Paria and Yuet (2006), Electric Power Research Institute (EPRI 2009a), and several state-of-the-practice reports produced by the U.K. Engineering and Physical Sciences Research Council's Stabilization/Solidification Treatment and Remediation Network (STARNET), available at www-starnet.eng.cam.ac.uk. These documents also contain numerous literature references for in-depth information on many technical aspects of S/S.

Sufficient research work has not been done in any literature concerning the Solidification/Stabilization of Incinerated hospital waste (IHW). Most of the research works and publications are on the Solidification/Stabilization of Incinerated hospital waste or (MSW) produce by power plants. So for as the utilization of IHW is concerned this is the beginning area for its study and application. Incinerated municipal solid waste or fly ash is potentially useful material for construction related work.

Abdul-Rashid and Frantz (1992) works on the physical properties of incinerated fly ash, are quite similar to coal fly ash evaluating engineering properties for geo technical application with large quantities of incinerated fly ash, there is an immediate need for acceptable disposal method other than land filling, which has become undesirable (Poran et.al,1989) several studies were carried out over the last few decades established that both coal fly ash and solid waste Incinerated fly ash have favourable engineering characteristic for geotechnical application (Sherwood and Ryley: shows et al,2003).

Genazzini (2004) works on hospital waste ashes on Portland cement develops the change of incorporating hospital waste ash in Portland cement. Ash characterization was performed by chemical analysis, X-ray diffraction, radioactive material detection, fineness and density test. Conduction calorimetric and setting time tests were developed on pastes including ash contents from 0% to 100%. Mortars were prepared including ash content up to 50% of cement. The result of setting time, temperature development, flexural and compressive strength, water absorption, density, an leach ability are analysed. Results indicate that Portland cement systems could become an alternative for the disposal of this type ash. Although the technological and economic benefits were the main reasons for the ash additions, the prevention of environmental contamination by means of proper waste disposal becomes a priority.

Azmi (2005) effective utilization of hospital waste molten slag produced using a high temperature melting system, and being operated at a hospital in Selangor, Malaysia. The hospital waste is incinerated and subsequently melted at 1200 C. Scanning election microscope result showed that the slag produced after melting contained amounts of SiO2, CaO and Al2O3 in excess of 53%,9% and 16% respectively. The result from the leaching analysis on the slag produced proved that the melting process had successfully stabilized the heavy metals. The use of this slag as an alternative material to replace conventional aggregates for the road construction was studies.

Rachana and Choudhary (2006) reviewed the various factor affecting hazardous waste they found that the performance of Solidified/Stabilized product can be improved by additives like fumes, sulphur polymers CaCl2 etc. Expensive soils have tendency to swell they come in contact with mixture and to shrink if moisture is removed from them. These volume changes in swelling soils are the cause of many problems in the structures that comes into their contact or constructed out of them. The expensive soils in India have liquid limit values ranging from 50-100%. Plasticity index ranging from 20-65% and shrinkage limit from 9-14% . The comprehensive review of literature shows that a considerable amount of work related to the determination of deformation characteristics and strength characteristics of expansive soil is done worldwide. Improving the strength of soil by stabilization technique was performed by Supakji Nontananandh (2004) and can Burak Sisman (2011).

Abielaala (2011) worked on fly ashes from incineration of waste infectious risk care (WIRC). The environmental problems of fly ashes from incineration of WIRC so called hospital waste collected from Marrakech City were used for these experiments. Sample of fly ashes and of both crude soluble and insoluble fractions were processed at temperature 100 and 300 C to be characterized using a diffractometer (Philips X'pert MPD) and a Scanning Electron Microscope (SEM). The chemically Composition of fly ashes was determined by inductively coupled plasma (ICO), where light element measured with device ultimate and heavy elements were determined using Panorama devices.

Zia Y.K. (2012) works on bricks were prepared using the soil mixed with IHW and RHA. Bricks were prepared after determining the optimum percentage of soli mixed with IHW and RHA which gave maximum strength. For pozzolanic activity lime was added to the mixture. The comprehensive review of literature shows that a considerable amount of work related to the compressive strength, bulk density, and water absorption of brick prepared is compared to brick made by mixing soilwith bagasse ash (Shashank Raghatate 2003). Heavy metals concentration was found in leachate test. Result found that incinerated hospital waste may be mixed with soil for application in geotechnical and construction works.

Khan A.H.(2013) works on Solidification/ Stabilization of IHW using chemical binder such as RBI GRADE-1. It is found that 12% IHW mixed the optimum binder content. Leachate studies work and find the confirm high concentration of toxicity heavy metals in soil and mixed with incinerated hospital waste. Heavy metals concentration in leachate of solidified sample is also studied and it is found that it meets the Indian Standards. It may also resolve the problem of effective disposal of the incinerated hospital waste.

V. S/S Technology Advantages and Limitations

Use of S/S to treat contaminated material has resulted in development of reliable information regarding effectiveness and other factors that are typically considered in the process to evaluate and select site remedial actions. In considering use of S/S technology, a sound understanding of site conditions is important, as well as an understanding of the practical outcomes and limitations of the technology.

S/S technology is applicable for a relatively broad range of contaminants and may be feasible when limitations to other technologies are imposed by site or contaminated material conditions. General non-site-specific advantages and challenges of S/S technology are listed below

(Environment Agency 2004a, EPRI 2009a). As with use of any technology, site-specific conditions determine the potential feasibility and effectiveness of S/S and therefore also determine the applicability of the advantages and challenges listed.

A. S/S Technology Advantages:

- effective in treating many inorganic contaminated materials has been shown effective in treating some materials contaminated with organic chemicals.
- option for treating recalcitrant or mixed contaminant may address NAPL through S/S treatment process often reaches fixed treatment end point in a relatively short period of time
- can improve structural property of soil, waste, and sludge (e.g., strength) to facilitate consideration of land beneficial reuse.
- applicable for in situ or ex situ treatment
- has been applied in dry or wet conditions, reducing dewatering and waste management issues
- generally uses simple, readily available equipment and materials
- on-site management of contaminated materials conserves landfill space and does not require transportation off site.
- may be more cost-effective than excavation and off-site disposal

B. S/S Technology Challenges:

- contaminants are not destroyed or removed; long-term stewardship may be required
- effectiveness for certain contaminants (such as some organics or highly mobile species) may require additional measures in testing and design potential changes in physical setting (e.g., groundwater flow, mounding) may need to be assessed uncertainties associated with prediction of long-term behavior
- options for treatment or post-treatment modifications limited by time for field performance testing and changed properties of treated material
- volume increases that occur in the treated mass may require management
- requires removal of debris or underground obstructions prior to treatment

VI. CONCLUSION

S/S treatment continues to enjoy significant use in the United States to treat industrial waste and contaminated media at remediation sites. EPA considers S/S to be an established treatment technology and has used the technology at 25% of the nation's Superfund program sites where the bases of contamination have been addressed. S/S technology can be used to treat a wide range of hazardous elements within the same media or waste. This flexibility is a key reason for the high incidence of use of the technology in remediation. S/S treatment shields human health and the environment by safely immobilizing contaminants within the treated material. S/S treatment is a useful technology for port facilities and nearby Brownfields sites S/S treated soils have improved construction characteristics allowing the soil to be reused at the redevelopment site. An appreciation of the versatility of the treatment technology can be gained by review of example projects. S/S is expected to continue to be an essential tool in waste management, remediation, and port improvement.

REFERENCES

[1] Conner, Jesse R., Chemical Fixation and Solidification of Hazardous Wastes, Van Nostrand Reinhold, New York, NY 1990.
[2] Conner, J. R. 1997. Guide to Improving the Effectiveness of Cement-Based Stabilization/ Solidification. Publication No. EB211. Skokie, Ill.: Portland Cement Association.
[3] EPA. 2000. Solidification/Stabilization Use at Superfund Sites. EPA/542/R-00/010. Office of Solid Waste and Emergency Response.
[4] EPA. 2010a. Background Information for the Leaching Environmental Assessment Framework(LEAF) Test Methods. EPA/600/R-10/170. Office of Research and Development.
[5] Robert Delisio, presented at the Cement Association of Canada, Remediation Technology Workshop: Solidification and Stabilization Treatment, Toronto, ON, Canada, May 2001 (unpublished).
[6] Department of the Army, U.S. Army Corps of Engineers, Guide Specification for Military Construction—Solidification/Stabilization of Contaminated Material, CEGS-02445, December 1995.
[7] R.L. Einhaus, P. Erickson, Fate Of Polychlorinated Biphenyls (PCBs) In Soil Following Stabilization With Quicklime, U.S.EPA, EPA/600/2-91/052, September 1991.
[8] K. Loest, C.M. Wilk. "Brownfield Reuse of Dredged New York Harbor Sediment by Cement-based Solidification/Stabilization" Proceedings of the 91st Annual Meeting & Exhibition, Air and Waste Management Association 1998.
[9] U.S.EPA. Stabilization/Solidification of CERCLA and RCRA Wastes—Physical Tests, Chemical Testing Procedures, Technology Screening, and Field Activities, EPA/625/6-89/022, May 1989.
[10] U.S.EPA. Engineering Bulletin—Solidification/Stabilization of Organics and Inorganics, EPA/540/S-92/015. May 1993.
[11] U.S.EPA. Technology Resource Document--Solidification/Stabilization and its Application to Waste Materials, EPA/530/R-93/012. June 1993.
[12] U.S.EPA. Innovative Treatment Technologies: Annual Status Report, 10th Edition, EPA-542-R-01-004, February 2001.
[13] L. Weitzman, J.R. Conner. "Descriptions of Solidification/Stabilization Technologies", Immobilization Technology Seminar—Speaker Slide Copies and Supporting Information, U.S. EPA, CERI-89-222, October 1989.
[14] Paswan, A. K. (2014), "Stabiilization/Solidification of Incinerated Hospital Waste." M.Tech Thesis, M.M.M.University of technology, Gorakhpur.
[15] Singh, K. L. (2013) and Jawaid, S. M. A. , " Geotechnical Properties of Soil Stabilized with Bagasse Ash",International Journal of Biological Science & Technological Research paper Vol. 1, No 9, pp1-4