A Hazardous Waste Management of Industrial Waste for Green Brick Deceit

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***Abstract*: The emancipation of industrial waste affects the marine environment by physical smothering and intoxication. Waste water hold organic solvents, heavy metals and massive pollutants compel through improper design, operation or treatment system, crafts foremost environmental issues when discharged. A giant amount of sludge is generated during treatment process caused a major trouble to industry. In this perspective, the present research work aims to widen an effective and advanced technique in solidification and stabilization of sludge for brick development. Dried sludge were utilize as additive with fly ash, stone dust, ordinary port land cement and water in various compositions for fabrication process. Compression, w ater absorption, efflorescence, soundness, XRF and TCLP tests were conduct to determine brick parameters.**

Keywords: Sludge, Brick, Pollutant

1. INTRODUCTION

The hazardous waste ejection from industries such as pharmaceutical industry is of prime concern in the recent decade, due to its toxic nature. Pharmaceutical industry often produced high-strength wastewater as well as sludge with unreliable quality and quantity limits depending upon their raw materials and manufacturing processes [1]. Perpetual storage of hazardous wastes required to be converted into non-hazardous forms by suitable pre-treatments [2]. Land filling, incineration, solidification/stabilization (S/S) and co-processing for cement industry are the disposal methods in practice. S/S method is the most preferable technique for managing the pharmaceutical sludge in a sustainable manner due to its stability.

Stabilization/Solidification (S/S) is a method where the different types of industrial wastes can be managed and particularly suited to those of heavy metal-containing wastes [3]. Stabilization refers to techniques that chemically reduce the hazard potential of a waste by converting the contaminants into less soluble, mobile or toxic forms, while solidification refers to techniques that encapsulate the waste, forming a solid material, and does not necessarily involve a chemical interaction between the contaminants and the solidifying additives [4].

In recent decades, numerous types of waste materials were assessed as raw materials for brick making: lightly contaminated harbor sediments [5-7], reservoir sediments mixed with fly ash [8], dried sludge collected from industrial wastewater treatment [9-11], and incinerated sewage sludge ash [12-14] and fly ash [15]. As a consequence, it is imperative to develop a new alternative for conventional solid soil bricks. Fortunately, preparation of hollow bricks based on the solid waste [16], especially fly ash [17-18], has gained fast development in recent years.

The key objectives of this study is to develop new brick on the basis of pharmaceutical waste with inclusion of other wastes (fly ash, stone dust, ordinary port land cement) in order to reduce brick production costs and decrease the use of natural resources.

II. MATERIALS & METHODS

Industrial wastes were collected from effluent treatment plants (ETP) of the pharmaceutical industries which were located in Mumbai, India. The materials and their purpose of use in brick production were given in Table I. The sludge were collected from industrial sites and dried in a hot air oven for 24 h at 105 °C and ground to less than 9.5 mm in size to aid workability of the sludge-ash-binder mixture during casting. The sludge and binders were mixed in a pan mixer with different compositions (MT1, MT2…MT5), and after 5 min, it was blended with water. The prepared admixes were filled in the moulds which had the internal dimensions of 230 mm×110 mm×70 mm and kept under moist condition for 24 h. The bricks were kept for curing for 14 and 28 days. The composition of the briquetting materials were reported in Table II.

TABLE I
Reactant materials used for study

Material	Purpose of use	Characteristic
Pharmaceutical industry waste/sludge	Needed to treat	Hazardous
Cement	Binder	Construction compound
Quarry dust	Strength enhancer	Hazardous
Pulverized fuel ash	CO-binder	Hazardous

TABLE II
Composition of the briquetting materials

Composition	Trial mixes in (wt %)				
	MT1	MT2	MT3	MT4	MT5
Fly ash	60	50	40	30	20
Cement	10	10	10	10	10
Stone dust	30	30	30	30	30
Sludge	0	10	20	30	40

Toxicity characteristic leaching procedure (TCLP) analysis, the solid samples were manually crushed to <1 cm and leached using an extraction buffer of acetic acid and sodium hydroxide (pH 4.93±0.05) at a liquid/solid ratio of 20:1. The extraction (at 25±2 °C) was performed by shaking the material for 18 h. Subsequently, the leachate samples were filtered, and the resultant TCLP extract (filtrate) is analyzed for heavy metals using atomic absorption spectroscopy (model: Atomic Absorption Sens AA Spectrometer).

The weight and temperature calibrations of the instrument was made using the reference weight and according to the sensor calibration of the instrument, respectively. The compressive strength of the composites was determined, according to SIST EN 12390-3:2009 after 14 and 28 days of moist curing, on 50-mm cube samples of the composites, prepared according to SIST EN 12390–2:2009.

III. RESULT & DISCUSSION

A. Mechanical properties of the brick products

Mechanical property of the bricks was evaluated in terms of unconfined compressive strength (UCS). The UCS were measured and represented in Table 4, and it was observed that MT1 corroborate maximum UCS in contrast with other samples. Brick curing with water lasted for 14 and 28 days, and the maximum UCS of samples MT1, MT2, MT3, MT4 and MT5 was observed to be 7.554, 6.441, 4.664, 3.557, and 2.313 N/mm^2, respectively, where the 14 day dried bricks showed 4.344, 3.623, 2.924, 2.292, and 1.116 N/mm^2 respectively. The compressive strength of the bricks increased in direct proportion to additive dosage (dust and fly ash). The reduction in UCS with increasing of sludge concentration was observed which might be due to the weakening of physical and chemical bonds between the components at the formation stage of bricks. All the bricks met the Indian standards class C (>4.0 MPa) bricks required UCS [19]. Indian minimum required UCS standards (<10 MPa) (IS: 3495–1976), Bureau of Indian Standards (BIS) and Bureau of Standards (IS: 12894–2002).

TABLE IV
Compressive strength of brick

Sample	Dimension of bricks			Avg. Area of bed surface (mm2)	14 days curing		28 days curing	
	Length (mm)	Width (mm)	Height (mm)		Max load at failure (KN)	Compressive strength (N/mm2)	Max load at failure (KN)	Compressive strength (N/mm2)
MT1	230	110	70	25300	110	4.344	191	7.554
MT2	230	108	72	24840	90	3.623	160	6.441
MT3	230	110	70	25300	74	2.924	118	4.664
MT4	230	110	70	25300	58	2.292	90	3.557
MT5	230	109	71	25070	28	1.116	58	2.313

B. TG-DTA of the brick

The thermo gravimetric thermal analysis (TG-DTA) of the sludge was carried in the temperature range between 100 a and 800 °C (Fig. 1). The gravimetric loss of all the brick was observed to be dividable into three zones, where the first zone of the mass loss might be attributed to the evaporation of physically and chemically bounded water, whereas the second zone of the mass loss might be due to the decomposition of the stable hydrates of the calcium aluminates and calcium silicates. The final zone might be due to the decomposition of the calcium carbonates at 780 °C. However, weight loss between temperature range of 223.3 and 520.3 °C is due to decomposition of partially burnt organic compounds. Differential temperature analysis represented an exothermic peak at 750 °C and an endothermic peak at 300 °C in all the five samples. Only 20 % of the weight loss was observed in the TG analysis. This 20 % weight loss might be attributed to metal hydroxide decomposition and ingredient organic matter.

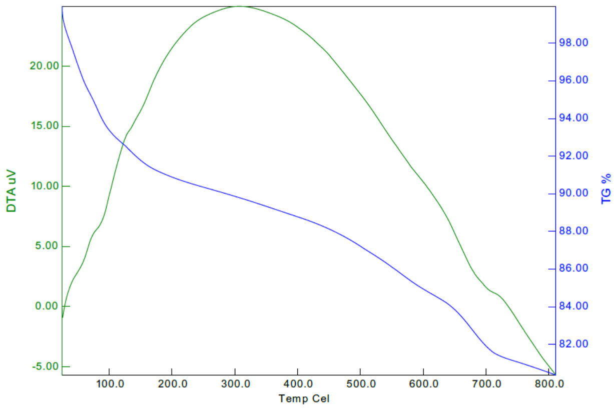

Fig 1. Thermogravimetric-differential temperature analysis of brick

C. Mineralogical analysis of the brick

X-ray diffraction (XRD) was used to determine the mineralogical properties of the bricks (Fig. 2). The crystalline phases of the bricks showed the presence of the following minerals: quartz SiO_2, calcite $CaCO_3$, illite $KAl_2(Si_3Al)O_{10}(OH)_2$, thenardite Na_2SO_4 and hematite Fe_2O_3. The main crystalline phase of these matrices was quartz and calcite. Intensity of quartz peak (21° and 27° (2θ)) was observed to be strong in all brick samples. Calcite peak (29° and 39° (2θ)) was also observed in all samples but the intensity was lower than that of the quartz peak. The presence of calcite is attributed to the carbonation of samples during the curing and brick preparation process.

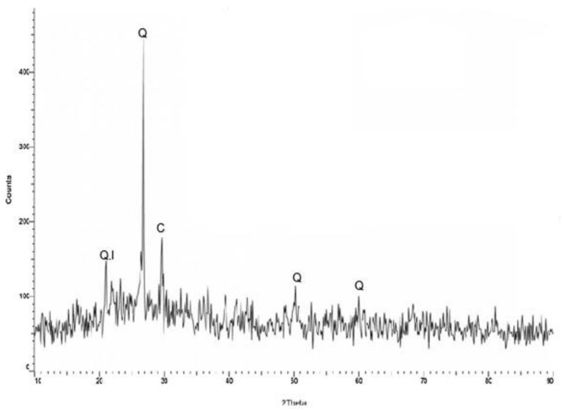

Fig 2. XRD pattern of brick

TABLE III.
Elemental analysis of sludge via ICP-AES

Elements	Result (%)
Cu	0.011
Zn	0.04
Fe	5.044
Pb	0.0036
Cd	ND
Co	0.0008
Cr	0.019
Ni	0.0125
As	ND
Hg	ND

D. Water absorption test

The water absorption of bricks is not directly associated with porosity owing to the nature of pores themselves. Several pores may be through pores which permit air to flee in absorption tests and allow free route to water in absorption tests, but other are completely seated and inaccessible to water under ordinary conditions. Therefore it is seldom possible to fill more than about three quarters of pores by simple immersion in water. Table 5 illustrate absorption test of bricks as per Indian standards, bricks contain sludge concentration in range of (0-10 %) for 14 days curing was tolerable but as compared with 28 days curing brick which shows improved result.

TABLE V.
Water absorption test of brick

Sample	Weight (dry) kg	14 days curing		28 days curing	
		Weight after 24 h (kg)	% of water absorption	Weight after 24 h (kg)	% of water absorption
MT1	2.683	3.052	13.75	3.187	18.78
MT2	2.679	3.162	17.33	3.202	19.53
MT3	2.666	3.168	18.82	3.218	20.70
MT4	2.666	3.198	19.95	3.250	21.90
MT5	2.683	3.258	21.43	3.311	23.40

IV. CONCLUSIONS

A. From this study, it was concluded that the pharmaceutical sludge could be used for the production of construction materials. Ten percent of sludge in the brick mixture provides good compressive strength.
B. Studies of XRD and TG-DTA were evidence for the formation of new materials.
C. Despite the content of heavy metals in the raw materials, leaching and solubility tests of the new products show advantageous values as compared to the Indian standards. Solidification/Stabilization will reduce the release of metals from the solid waste.
D. The use of this method is highly profitable, in view of the fact that the use of common industrial wastes significantly reduces the cost of the end production in comparison to traditional natural materials and essentially reducing the exploitation of natural raw materials.

REFERENCES:

[1] Nithyanandam R, Saravanane R (2013) Treatment of pharmaceutical sludge by Fenton oxidation process. Int J Chem Eng Appl. doi:10.7763/IJCEA.2013.V4.325
[2] Aydın AA, Aydın A (2014) Development of an immobilization process for heavy metal containing galvanic solid wastes by use of sodium silicate and sodium tetraborate. J Hazard Mater. doi:10.1016/j.jhazmat.2013.12. 017
[3] DellOrso M, Mangialardi T, Evangelista Paolini A, Piga L (2012) Evaluation of the leach ability of heavy metals from cement-based materials. J Hazard Mater. doi: 10.1016/j.jhazmat.2012.04.017
[4] Montanes MT, Sanchez T, Roux MS (2014) The effectiveness of the stabilization/solidification process on the leachability and toxicity of the tannery sludge chromium. J Environ Manag.doi:10.1016/j.jenvman.2014.04. 026
[5] Hamer K, Karius V (2002) Brick production with dredged harbour sediments. An industrial-scale experiment. Waste Manag. DOI:10.1016/S0956-053X(01)00048-4
[6] Hamer K, Waschkowitz C, Isenbeck-Schroter M, Schulz HD (1999) Harbour sediments for brick production. Ressourcen-Umwelt-Management, Schriftenreihe der Gesellschaft fur Umwelt Geowissenschaften (GUG), Koln, pp 223–240
[7] Karius V, Hamer K (2001) PH and grain-size variation in leaching tests with bricks made of harbour sediments compared to commercial bricks. Sci Total Environ. doi:10.1016/S0048-9697(00)00889
[8] Hsu YS, Lee BJ, Liu H (2003) Mixing reservoir sediment with fly ash to make bricks and other products. In: International ash utilization symposium. Center for Applied Energy Research, University of Kentucky, paper#89.
[9] Liew AG, Idris A, Samad AA,Wong CHK, Jaafar MS, Baki AM (2004) Reusability of sewage sludge in clay bricks. J Mater Cycles Waste Manage 6:41–47. doi:10.1007/s10163-003-0105-7
[10] Lin DF, Wenig CH (2001) Use of sewage sludge ash as brick material. J Environ Eng 127(10):922–927
[11] Weng CH, Lin DF, Chiang PC (2003) Utilization of sludge as brick materials. Adv Environ Res 7:679–685. doi:10.1016/S1093-0191(02)00037-0
[12] Anderson M, Skerratt RG, Thomas JP, Clay SD (1996) Case study involving using fluidised bed incinerator sludge ash as a partial clay substitute in brick manufacture. Water Sci Technol 3–4:195–205
[13] Anderson M, Elliott M, Hickson C (2002) Factory scale trials using combined mixtures of three by-product wastes (including incinerated sewage sludge ash) in clay building bricks. J Chem Technol Biotechnol 77:345–351. doi:10.1002/jctb.593
[14] Wiebusch B, Ozaki M, Watanabe H, Seyfried CF (1998) Assessment of leaching tests on construction material made of incinerator ash (sewage sludge). Investigations in Japan and Germany. Water Sci Technol 38:195–205
[15] Lingling X, Wei G, Tao W, Nanru Y (2005) Study on fired clay bricks with replacing clay by fly ash in high volume ratio. Construct Build Mater 19:243–247. doi:10.1016/j.conbuildmat.2004.05.017
[16] JianfengWU, Fangwen LI, Xiaohong XU, Xianli SU (2008) Preparation of eco-environmental protection bricks from lake sludge. Preparation of Eco-environmental Protection 23:912–16. doi:10.1007/s11595-007-6912-2
[17] Lingling X, Wei G, Tao W, Nanru Y (2005) Study on fired clay bricks with replacing clay by fly ash in high volume ratio. Construct Build Mater 19:243–247. doi:10.1016/j.conbuildmat.2004.05.017
[18] Dondi M, Guarini G, Raimondo M (2002) Orimulsion fly ash in clay bricks—part 2: technological behaviour of clay/ash mixtures [J]. J Eur Ceram Soc 22:1737–1747. doi:10.1016/S0955-2219(01)00494-0
[19] Vsevolod Mymrin, Ricardo A C Ribeiro, Kirill Alekseev, Elena Zelinskaya, Natalia Tolmacheva, RodrigoCatai (2014). Environment friendly ceramics from hazardous industrial wastes. Ceram Int. doi: 10.1016/j.ceramint.2014.02.014.