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Research paper

Blended binder system with Incinerated Paper Ash (IPA) for Solidification/Stabilization (S/S)

Mazni Mat Zin*, Azyan Zafyrah Mohd Zahid, Noorashiekin Khalid, Nadia Zalikha Saifullizam, Wan Syarizawani Wan Chik, Siti Farahin Kamaruddin, Siti Shahidah Sharipudin, Nor Mayuze, Mohd Johan Ibrahim, Saiful Jumali, Nurul Ain Umaiban Yusof[1]

Faculty of Civil Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, 81750 Johor, Malaysia
**Corresponding author E-mail: mazni9746@johor.uitm.edu.my*

Abstract

This research explored the potential to use IPA as a binder for the treatment of industrial waste sludge. Within the study, Incinerated Paper Ash (IPA) was used together Ordinary Portland Cement (OPC), a main material employed in solidification/stabilization (S/S) methodology to treated industrial ceramic sludge. The issues created by OPC in sustain the surroundings and cost force the new material must replace OPC as binder within the treatment methodology. The impact of the various IPA compositions within the system has been examined. The Unconfined Compressive Strength (UCS) and Toxicity Characteristic Leaching Procedure (TCLP) were used to assess the viability of IPA in sludge treatment once 28 days. The great result of compressive strength and decrease in heavy metals shows the potential of IPA in OPC replacement.

Keywords: *Solidification; Stabilization; Portland cement; IPA; Ceramic sludge.*

1. Introduction

The preservation of the surroundings and community health from hazardous waste products has forever been a crucial priority for many industrial nations. With the advancement in technology, there has additionally been an increase within the quantity of waste sludge created from these advanced processes. Landfilling such sludge is most ordinarily practiced. However, there are several limitations to the current method together with heavy metals leaching into the atmosphere at the dumpsite. Because the accumulation of heavy metals have a major impact on the organic phenomenon, the treatment of hazardous sludge before disposal is critical.

Sludge that consists of heavy metal is that the second most sizably voluminous waste engendered in Malaysia. Close to 60200 tonnes/year of ceramic sludge were formed in year 2002. As according by [1] in their study, it is expected concerning 30% of the assembly within the ceramic industry generate a waste whereas nowadays, the waste is not being recycled or reusable. In step with [2, 3], the ceramic industry releases a big quantity of heavy metals. Costly and not appropriate treatment because of new options to legitimately deal with and deal with the expanding of ceramic sludge should be any investigated. Some different ways of treating sludge are known and one of the innovations still prominent is the method of stabilization / solidification (S/S).

S/S technique purposes at immobilizing pollutants by transform them into a less soluble form (stabilization), and enclose them by the creation of a sturdy matrix (solidification) [4]. As declared by [5], it is recognized as “the best demonstrated offered technology” for industrial waste treatment involve heavy metals.

Basically, the S/S technique contains a combination of chemical binders with sludge and water before cementitious mixture is cured for many days. The identification of binders is vital for the success of the technique [6]. This statement is supported by [7], according that the binder and therefore the waste should be with chemicals act with each other so as to make chemical bonding. These varied kinds of S/S binders have totally different S/S impact on varied kinds of hazardous waste [8]. Studies by [9] shown that the ordinary cement (OPC) is usually used as a binder in S/S technique. However, as according by [10], the matter concerning to OPC to sustain the environment and production cost produce a controversy to the industry. New material has been utilized in exchange OPC by exploitation Incinerated Paper Ash (IPA)

The incinerated paper ash (IPA) could be a massive contributor to major economic and environmental drawback in paper production because it is extravagantly being made by the paper newsprint industry. The blending of water with IPA shows that its will process cement-like behavior [11]. This statement in-line with [12] expressed that IPA contains substantial chemical composition which will be used as a novel cement replacement material. Moreover, the increasing of IPA turn out by Malaysia Newspaper Industry (MNI) cause the quantity of paper continues to rise and therefore the price of disposal is around half the value of waste treatment [13]. Thus, there is a desire to produce a good answer in treating the waste and control natural resources.

2. Material and methods

This section elaborates on the preparation of raw materials used and methodology to execute the research study. The materials used were divided into two groups which are ceramic sludge and the binder.

2.1. Materials

The sludge was collected at Senawang Industrial Estate, Negeri Sembilan, Malaysia and was oven-dried at 110°C for a day then sieve to fine powder to manage the sludge quality until the test day. The sludge treatment was performed using Type 1 Ordinary Portland Cement (OPC) and in the midst of IPA. The OPC was from Cement Industry of Malaysia (CIMA) while IPA was obtained at Malaysia Newsprint Industries (MNI) mill at Temerloh Industrial Park, Pahang. Chemical compositions in the material are shown in Table 1.

Table 1: Chemical compositions of materials

Element	Ceramic Sludge	OPC	WPSA
CaO	11.4066	63	50.6701
SiO_2	53.3547	20	13.9637
Al_2O_3	7.8676	5.7	9.3622
MgO	<LOD	0.99	4.2316
Fe_2O_3	0.472	2.9	0.7084
SO_3	<LOD	3.5	0.194
Zn	3.2322	0.005	0.0103
Cu	<LOD	0.003	0.0459
Cd	<LOD	<LOD	< LOD
Ni	0.0367	0.011	< LOD
Pb	0.1857	0.001	0.004
Cr	0.02	0.0063	< LOD

2.2. Mixed formulation and production of solidified/stabilized samples

Table 2 represents the design mixtures for this study. The OPC has been added together with ceramic sludge at ratio water to mixture 0.5. 100% OPC also prepared as a control. The mixture was cast and de-mould after 24 hours. The cube was tested for solidification at 28 days of water curing. The best mix design was determined according to the design with the highest sludge content, in accordance with the S / S specification.

Table 2: Design mixture

Mix	OPC (%)	Ceramic Sludge (%)
M1	100	0
M2	80	20
M3	60	40
M4	40	60
M5	20	80

2.3. Testing protocols

The compressive strength test was applied to the cube samples at 28-day water curing to determine the optimal sludge. The mix with the highest percentage of sludge with satisfied strength was selected as optimum sludge to be treated with the blended binder. Table 3 shows the mix proportion of binder with the sludge.

Table 3: Mix proportion

Mix	OPC (%)	Ceramic Sludge (%)	IPA (%)
M1	40	60	-
M6	30	60	10
M7	20	60	20
M8	10	60	30
M9	-	60	40

The interval of 10% replacement was selected for mix proportion of IPA as reported by [14], replacement of 10-20% mineral waste by weight will enhance the compressive strength of concrete.

After 28 days of water curing, the cube samples were tested for the unconfined compressive strength test [14]. Crushed block Leaching test were conducted at 28 days of curing in accordance with (TCLP) method 1311 [15]. The concentrations of heavy metal in leachate were determined and heavy metals in raw materials were performed using the X-Ray Fluorescence (XRF) method.

3. Results and discussion

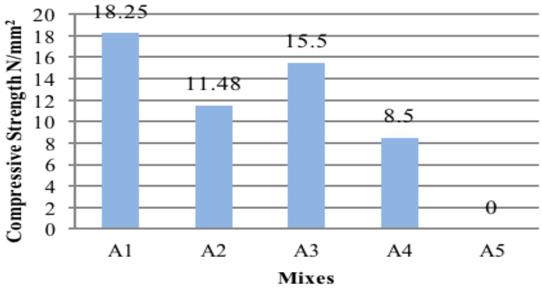

Fig. 1: Compressive strength at 28 days

From Fig.1, the result presented that A4 is the ideal mixes with ratio OPC: sludge at 60:40 with compressive strength 8.50 N/mm^2. In conjunction with that, the percentage of ceramic sludge will be treated with the binder is 60%. The ideal mix design of IPA was examined after the optimum sludge was obtained. Table 3 presents mix proportions of IPA with OPC and ceramic sludge. The mixture was cast (for unconfined compressive strength, UCS and leachability determinations) then de-mould after 24 hours. All sample then test at 1, 3, 7, and 28 days.

3.1. Impact of WPSA on ceramic sludge solidification

From the results obtained, it shows that the optimum percentages of IPA used at 10% give the highest compressive. This result obtained was supported from the previous study by [13], found that 5% replacement of OPC by mineral waste will improve the compressive strength with increasing curing time.

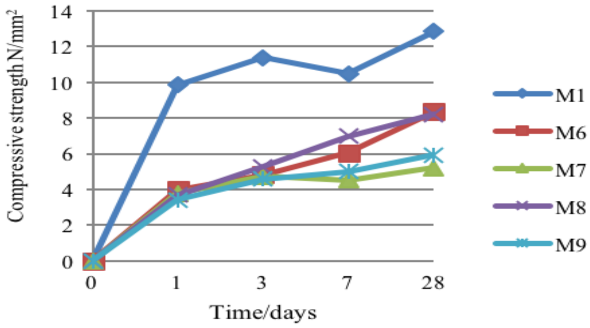

Fig. 2: Influence of IPA to the solidified sludge

The difference in the result obtained because of several factors. As reported in [10], dissimilar waste metals have altered the effects of a treated product individually. The existence of heavy metal in S/S treatment can influence the cementation process. The result is supported by previous study stated by [3], found that the different concentration of heavy metal in the S/S treatment will influence the result of solidified sludge treated.

3.2. The influence of IPA to stabilize ceramic sludge

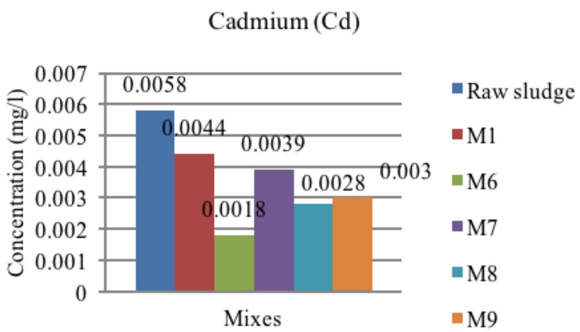

Fig. 3: Concentration of Cadmium (Cd)

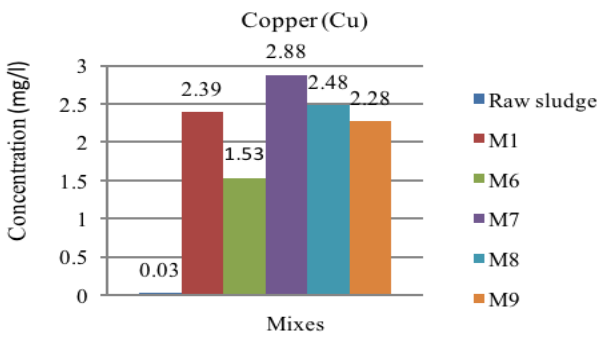

Fig. 4: Concentration of Copper (Cu)

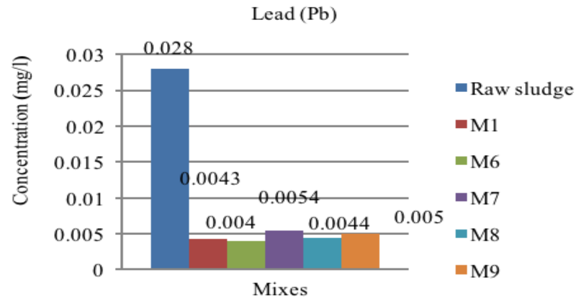

Fig. 5: Concentration of Lead (Pb)

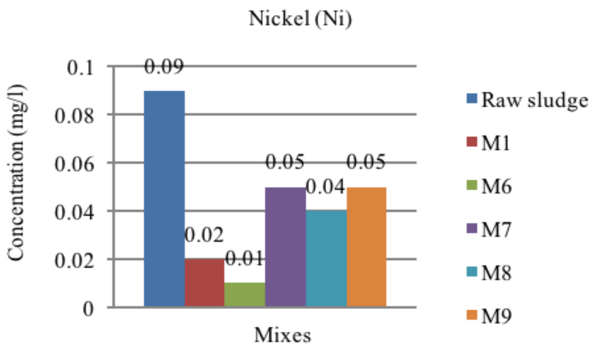

Fig. 6: Concentration of Nickel (Ni)

The influence of IPA to stabilize the sludge obviously reduces the heavy metal concentration in the sludge after the treatment, but the result indicates an increase in concentration of Copper (Cu). An increase in the concentration of Cu in S/S product is influenced by the binder and the different composition of IPA being used. However, all the results obtained meet the limit as set out in the standard requirement.

4. Conclusion

The ideal IPA mix design for generating a mixed binder system for the treatment of industrial ceramic sludge is 10:60. Besides, this study shows that IPA was extremely potential to be a binder in exchange OPC. The higher proportion of siliceous and aluminous in IPA will produce hydraulic reaction to enhance strength in S/S matrix. Indeed, the impact of IPA on the behavior of sludge will be determined by analysis stabilize product. IPA contains a risk to be used as a supplement in stabilizing ceramic sludge, as the heavy metal concentration meets the standard demand after treatment.

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