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TERNARY BLENDED BINDER SYSTEM (TBBS) FOR SOLIDIFICATION/STABILISATION (S/S) TECHNIQUE IN TREATING LIQUID MINERAL SLUDGE

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ABSTRACT

Solidification/Stabilisation (S/S) technique is always being a chosen treatment and disposal of hazardous wastes accepted by the industries. It is one of the treatments for sludge that promotes resource recycling and reduces the environmental burden of waste management. To accomplish this technique successfully, two (2) liquid mineral sludge; water treatment sludge (WTS) and ceramic sludge (CS) were treated with different binder systems using S/S technique. Binders made of industrial waste materials were examined. Three (3) Ternary Blended Binder System (TBBS) formulations incorporating Waste Paper Sludge Ash (WPSA), Palm Oil Fuel Ash (POFA) and Fly Ash (FA) were developed for the S/S technique. The liquid mineral sludge was treated by using the TBBS formulations of OPC-WPSA-POFA, OPC-WPSA-FA and OPC-POFA-FA. The WPSA, POFA and FA were blended to replace Ordinary Portland Cement (OPC) in S/S technique. Solidification (compressive strength) and stabilisation (metals leachability) tests were conducted on the solidified/stabilized liquid mineral sludge. Compressive strength test was conducted on solidified/stabilized liquid mineral sludge cured at age 1, 3, 7, 28, 56, 90, 180 and 365 days. Metals leachability test was only conducted for solidified/stabilized liquid mineral sludge cured until age 28 days. Binary Blended Binder System (BBBS) of OPC-WPSA, OPC-POFA and OPC-FA as well as standalone OPC used to treat the liquid mineral sludge was also tested for comparison. Additionally, the microstructures of the solidified/stabilized liquid mineral sludge were analysed using Scanning Electron Microscopic (SEM). As a result, the compressive strength of solidified/stabilized liquid mineral sludge were all exceeded the allowable limit at disposal site (0.34 MPa) in accordance to disposal site in UK. The compressive strength of solidified/stabilized liquid mineral sludge by formulated TBBS were in the range of 0.7 to 1.5 MPa at age 28 days. The chemical compositions of the WPSA, POFA and FA were affecting in most S/S of the liquid mineral sludge. Metals examined were cadmium (Cd), chromium (Cr^{6+}), lead (Pb), nickel (Ni) and copper (Cu). All metals were leached below the allowable limit of 1.0, 5.0, 5.0, 100.0 and 100.0 mg L^{-1} respectively as stipulated by Kualiti Alam, Malaysia. The major factor for metals to leach from the solidified/stabilized liquid mineral sludge was pH condition. The TBBS induce high pH that promote encapsulation, precipitation and adsorption into calcium silicate hydrate (C-S-H) gel in the solidified/stabilized liquid mineral sludge. Porous microstructures of the solidified/stabilized liquid mineral sludge also contributed to metals leachability. The microstructure images captured by SEM were consistent with the compressive strength and metals leachability results. Compact microstructure showed high in compressive strength and low in metals leaching concentration. The acquired data was then analysed to generate the S/S rate value for the solidified/stabilized liquid mineral sludge. The highest S/S rate value determine the efficiency of the formulated TBBS in treating liquid mineral sludge.

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CHAPTER ONE
INTRODUCTION

1.1 Background of Study

Solidification/Stabilisation (S/S) technique is always being a chosen treatment and disposal of hazardous wastes accepted by the industries. It is an established technique which offers an effective means of treating either organic, inorganic, or organic and inorganic wastes including soils (Yin et.al., 2006; Su et.al., 2009; Ganjidoust et.al., 2009; Antemir et.al., 2010; Voglar & Leštan, 2011; Burlakovs & Kļaviņš, 2012; Li & Poon, 2017), sediments (Zentar et.al., 2012; Furlan et.al., 2018, L. Wang, Chen et.al., 2018), industrial sludges (Bednarik et.al., 2004; Gailius et.al., 2010; Zain et.al., 2010; Arsenovic et.al., 2012; Chiki et.al., 2012; Patel & Pandey, 2012; Bayar & Talinli, 2013; Chindaprasirt et.al., 2013; Bocanegra et.al., 2017), oil (Cantarel et.al., 2015) and industrial ashes (Vinter et.al., 2016; Xian et.al., 2017). It is a physical-chemical process that aims to prevent water and toxic contaminants leach from the waste through encapsulation using binder system so that the waste becomes solid and is safe for disposal (Kuchar et.al., 2005; Ma et.al., 2010; Gollmann et.al., 2010; Hunce et.al., 2012; Patel & Pandey, 2012; Montañés et.al., 2014). However, limited results have been presented on treatment of sludge especially water treatment sludge (WTS) and ceramic sludge (CS) using S/S technique with various binder systems lead to development of Ternary Blended Binder System (TBBS), prompted the present research.

Ordinary Portland Cement (OPC) is the main binder system used for S/S technique due to its major compounds of tricalcium silicate (C_3S) and dicalcium silicate (C_2S) (Roy et.al., (1993) and Batchelor, (2006)). Due to this, the OPC has capability to generate a better strength throughout the hydration process when combine with water and able to transform waste into solid form. The advantages of using OPC are that it is able to chemically bind free liquids, reduce the permeability and solubility of waste, encapsulate hazardous compounds with an impermeable coating and reduce the toxicity of the contaminants (Paria & Yuet, 2006; Okoronkwo et.al., 2018). Nevertheless, recent research on S/S technique focused primarily on standalone OPC system or binary binder system for example with the incorporation of established pozzolans such as fly ash