STABILIZATION AND SOLIDIFICATION OF PALM OIL MILL EFFLUENT SLUDGE AND A PURE MODEL STUDY USING CEMENTITIOUS TECHNIQUE

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ABSTRACT

This research studies the effectiveness of using method of stabilization and solidification (S/S) to palm oil mill effluent (POME) sludge as a pretreatment method prior to ultimate disposal to land and to investigate the effect of varying the concentration of simulated metals (zinc, copper and iron) for pure model study (PMS). The characteristics of the solidified products including unconfined compressive strength (UCS) and toxicity characteristic leaching procedure (TCLP) from USEPA were evaluated. The influence of cement replacement material (CRM), namely pulverized fly ash (PFA) on the effectiveness of S/S was also investigated for POME sludge.

The POME sludge was stabilized using ordinary portland cement (OPC) with cement-dry sludge (C/S_d) ratios of 6, 7, 8, 9 and 10. PFA was used to replace cement at 5 %, 10 %, 15 %, and 20 % based on evaluated C/S_d ratios. For PMS, the metals of concern were copper, iron and zinc. The concentrations of copper used were 7 ppm, 34 ppm, 133 ppm, 228 ppm and 321 ppm. For iron, the concentrations used were 7 ppm, 34 ppm, 133 ppm, 230 ppm and 323 ppm while the concentrations of zinc used were 7 ppm, 34 ppm, 134 ppm, 232 ppm and 327 ppm. The strengths of the solidified sludge were obtained at 1, 3, 7, 14, 28 and 56 days.

Toxicity characteristic leaching procedure (TCLP) was performed after 28 days of curing. Two types of leachant were used to study the leaching mechanism of treated

sludge, namely 0.5M acetic acid (HAc, pH=2.89) and deionised water (pH=7.1). Metals of concern were lead, copper, zinc and iron. Metals were determined by using inductive couple plasma (ICP). UCS results showed that the strength increased with increasing of C/S_d ratios and proportion of PFA. Sample of C/S_d of 10 and containing 20% PFA gave the best UCS result of 3.38 N/mm^2 at 56 days. The UK legal limit for UCS is 0.34 N/mm^2.

The leachate analysis has indicated that all the samples comply with the regulatory requirement of metal concentration of 5 ppm. From the analysis, the sample with C/S_d ratio of 10 and 20 % PFA addition can be considered as the most suitable mix design to be adopted. For PMS, metals concentration of 34 ppm gave the best UCS results for all metals. It was observed that the presence of inorganic materials decreased the strength of OPC and increased the amount of metals released in leaching studies.

ABSTRAK

Kajian ini dijalankan bagi menyelidik keberkesanan menggunakan kaedah pemejalan dan penstabilan ke atas enapcemar kelapa sawit sebagai kaedah pra-perawatan sebelum dibuang ke tapak pelupusan dan mengkaji kesan mempelbagaikan kepekatan logam-logam simulasi iaitu zink, kuprum dan besi. Sifat-sifat produk yang dipejalkan telah dikaji dengan menggunakan ujian-ujian seperti kekuatan mampatan dan pengurasan. Bagi enapcemar kelapa sawit, pengaruh bahan penggantian simen iaitu abu terbang (PFA) telah dikaji ke atas keberkesanan penstabilan dan pemejalan.

Enapcemar kelapa sawit telah distabilkan menggunakan simen portland biasa (OPC) dengan nisbah simen-enapcemar kering (C/S_d), 6, 7, 8, 9, 10. Abu terbang telah diguna untuk menggantikan simen dengan peratusan 5 %, 10 %, 15 %, 20 % berdasarkan nisbah C/S_d. Bagi kajian model tulen (PMS), logam-logam yang dikaji adalah kuprum, besi dan zink. Kepekatan kuprum yang digunakan adalah 7 ppm, 34 ppm, 133 ppm, 228 ppm dan 321 ppm. Bagi besi, kepekatan yang digunakan adalah 7 ppm, 34 ppm, 133 ppm, 230 ppm dan 323 ppm sementara kepekatan zink adalah 7 ppm, 34 ppm, 134 ppm, 232 ppm and 327 ppm. Kekuatan bagi enapcemar dan logam simulasi telah dilakukan pada usia pengawetan 1, 3, 7, 14, 28 dan 56 hari.

Ujian pengurasan telah dijalankan selepas 28 hari usia pengawetan. Ujian kurasan telah dilakukan dalam dua medium iaitu 0.5 M asid asetik (pH=2.89) dan air suling (pH=7.1). Kandungan logam telah dianalisis dengan menggunakan plasma terganding induktif (ICP). Keputusan ujian mampatan menunjukkan bahawa

kekuatan meningkat dengan peningkatan C/S_d dan kandungan PFA. Had undang-undang UK bagi ujian kekuatan ialah 0.34 N/mm^2.

Analisis kurasan menunjukkan yang semua sampel mematuhi kehendak undang-undang dengan kepekatan logam 5 ppm. Dari analisis juga menunjukkan campuran dengan nisbah C/S_d 10 dan 20 % PFA memberikan kekuatan tertinggi. Untuk PMS, kekuatan tertinggi dicapai pada kepekatan logam 34 ppm bagi ketiga-tiga logam. Berdasarkan kajian ini didapati kehadiran bahan-bahan tak organik boleh mengurangkan kekuatan OPC dan meningkatkan jumlah logam yang terkuras keluar.

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SYMBOLS AND ABBREVIATIONS

ANSLT	-	American nuclear society leach test
BOD	-	Biological oxygen demand
CPO	-	Crude palm oil
CBL	-	Crushed block leaching
C-S-H	-	Calcium silica hydrate
CRM	-	Cement replacement material
C/Sd	-	Cement to dry sludge ratio
DLT	-	Dynamic leach test
DW	-	Deionized water
DOE	-	Department of Environment
EP	-	Extraction procedure
EPA	-	Environment Protection Agency
ELT	-	Equilibrium leach test
GAC	-	Granular activated carbon
HAc	-	Acetic acid
HDPE	-	High density polyethylene
ICP-OES	-	Inductively coupled plasma-Optical emission spectrometry
JIS	-	Japanese Institute of Standard
MC	-	Moisture content
MEP	-	Multiple extraction procedure
MWEP	-	Monofilled waste extraction procedure
OPC	-	Ordinary Portland cement
POME	-	Palm Oil Mill effluent

PFA	-	Pulverised fly ash
RCRA	-	Resource, Recovery and Conservation Act
SG	-	Specific gravity
S/S	-	Stabilization and solidification
SET	-	Shake extraction test
SAPLT	-	Synthetic and precipitation leach test
SLT	-	Sequential leach test
SVE	-	Soil vapor extraction
TCLP	-	Toxicity Characteristic Leaching Procedure
UCS	-	Unconfined compressive strength
VOC	-	Volatile organic compound
W/C	-	Water to cement ratio