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LEACHABILITY OF FIRED CLAY BRICK INCORPORATING WITH SLUDGE WASTE FROM MOSAIC INDUSTRY

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Abstract. The amount of sludge wastes from industrial, mining, domestic agriculture activities are about 60200 tons per year. The increasing of the waste will have significant impact towards environment and energy conservation. Many attempts have been made to incorporate sludge waste into brick for example fly ash sludge, sewage sludge, water sludge and ceramic sludge and advantages on the properties have been found but heavy metals leachibility will be the main concerned. Therefore, sludge waste is a potential alternative to convert into useful products as a building material that can alleviate the disposal problems. Therefore, in this study, the characteristics of heavy metals were determined by using XRF. Four different mixing ratios of mosaic sludge waste at (0%, 1%, 5%, and 10%) were incorporated into fired clay brick. Each brick was fired in a heat controlled furnace at elevated temperatures of 1050°C. The characteristic of heavy metals from the sludge waste were determined by XRF and the result show that the sludge waste is high in iron (Fe) and Zicronium (Zr) followed by Barium (Br), Chromium (Cr), Cadmium (Cd), Copper (Cu) and Zinc (Zn). The leachability of heavy metals from the manufactured mosaic sludge brick were determined by using toxicity characteristic leachibility procedure (TCLP) and the results demonstrated that the culprit heavy metals were all complied to USEPA(1996) and EPAV(2005a).

Introduction

According to Malaysia Environment Quality Report (2002)[1], heavy metals from sludge are the second largest waste in Malaysia generated by industrial activities. The amount of sludge wastes from industrial, mining and domestic agriculture activities are about 60200 tons per year. Industrial also facing problems of finding other alternative to deal with the sludge disposal and at the same time to meet the standard to preserve the environment. For disposal implement action, the government needs to focus to a large space and require a very large cost including transportation such as maintenance for the disposal operation. Inorganic content of industrial sludge such as heavy metals should get the specific treatment to prevent environmental pollution The main issues of the production from sludge industry is because sludge waste arising every year and give an impact to the environment for the future and the waste is not reused for any purposes [2]. Mosaic manufacturing process is one of the industries that produce high amount of sludge. The process of cutting the stones will produces heat, slurry, semi-liquid, rock fragments and dust that release chemical compounds colored and gases that contribute water pollution and global warming. Mostly ceramic product produce chemical content such as silica (SiO_2), alumina (Al_2O_3), lime (CaO), alkaline oxides and magnesium oxides [4]. High concentration of heavy metals are also detected in mosaic sludge waste such as Cadmium (Cd), Copper (Cu) and Zinc (Zn).

Bricks are one of the common buildings material due to its properties such as compressive strength, durability, excellent fire, weather resistance, sound insulation and easy to handle [3]. Many attempts have been made to incorporate sludge waste into brick for example fly ash sludge, sewage sludge, water sludge and ceramic sludge[4,5,6,7]. The addition of sludge waste into brick will provide positive impact for the environment, at the same time increase the performance of brick properties. Use of sludge as construction material can convert the waste into useful products to alleviate the disposal problems. Thus, recycling mosaic sludge waste could be one of the best alternative methods in terms of environment as well as economical. Nevertheless, the investigation on the leachability of heavy metals from the sludge waste always being neglected. Therefore, the aim of this study was to incorporate the mosaic sludge waste in the clay brick and to determine the leachability of heavy metals.

Materials and method

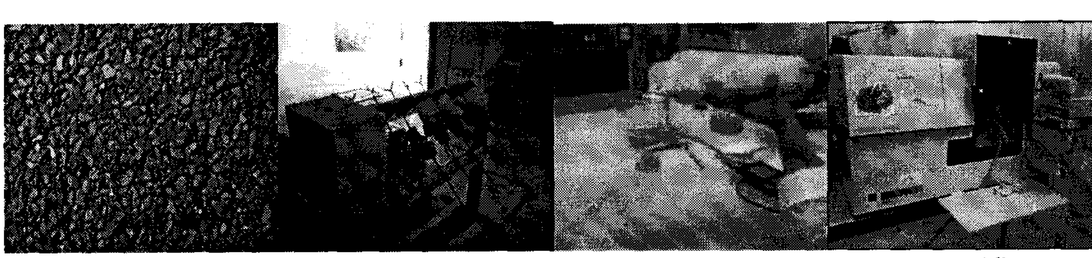
Material

Mosaic sludge waste that was incorporated to brick was collected at the Malaysia Mosaic Berhad (MMB) at Kluang, Johor. During sludge waste collection, safety equipment and procedure have to be followed. Sludge mosaic was kept before being used. Clay soil was obtained at Hup Seng Company, Sedenak Johor. These two raw materials were kept properly in a closed container and been storage at the laboratory before being used.

Method

Mosaic sludge and clay soil were dried in the oven for 24 hours. After the drying process the mosaic sludge and clay soil were crushed to sieve process. The mosaic sludge and clay soil were prepared in pellet shape before being tested in X-ray fluorescence (XRF) machine at the Analytical Environment Laboratory.

The TCLP in this study was prepared in Wastewater Laboratory in UTHM. Samples brick were crushed and divided into four parts to obtain representative sample to conduct the test. After crushed, all samples were sieved through 9.5mm (Fig. 1a). The 50g solid samples were placed in a 1L high-density polyethylene plastic bottle. The extraction fluid for 1L contained 5.7mL of glacial acetic acid with water. The bottles were placed in a rotary extractor at 30rpm at 22°C to 24°C for 18±2 hour (Fig.1b). At the end of the extraction, the samples were filtered through 0.7μm with glass fiber (Fig. 1c). Finally, the concentrations of heavy metals were measured by Atomic Absorption spectrophotometer (AAS) (Fig. 1d).



(a) (b) (c) (d)

Fig. 1: TCLP test process

Results and discussion

X-ray fluorescence (XRF)

The characteristic of clay soil and sludge mosaic waste produced was obtained by using XRF. The major chemical compositions of clay soil are Iron oxide (Fe_2O_3) and Zirconium (Zr) with the concentration of 55600ppm and 336ppm respectively. On the other hand, the highest chemical composition of sludge mosaic also were Iron oxide (Fe_2O_3) and Zirconium (Zr) were 11500ppm and 2416ppm respectively. High concentration of heavy metals are also detected in mosaic sludge waste such as iron (Fe) and Zicronium (Zr) followed by Barium (Br), Chromium (Cr), Cadmium (Cd), Copper (Cu) and Zinc (Zn).

Toxicity characteristic leachibility procedure (TCLP)

Based on XRF result from mosaic sludge waste produced, only few of high concentration heavy metals are selected for TCLP test which are Cadmium (Cd), Iron (Fe), Zinc (Zn) and Copper (Cu). The concentration are Cadmium (Cd), Iron (Fe), Zinc (Zn) and Copper (Cu) were tested at different percentages of the sludge mosaic waste incorporation inside the fired clay brick.

Concentration of Zinc (Zn)

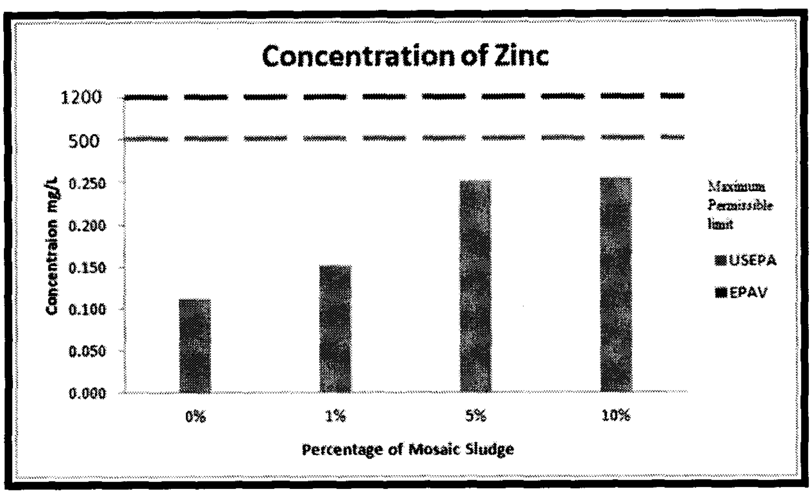


Fig. 2: Concentration of Zinc in mosaic sludge brick

According to Fig. 2 , it shows that the highest concentration of Zn is at 10% of mosaic sludge brick with 0.254mg/L and followed by 0.251mg/L at 5% of mosaic sludge brick. The lowest percentage was at 0% mosaic sludge brick with average of 0.111mg/L. According to Boonsaner (2006),[8] Zinc is generally added during industrial activities to help the production process and Zinc may cause anemia and pancreases damaged to human beings when being exposed. Nevertheless, from the results obtained, the leachibility of the heavy metals from mosaic sludge after the incorporation into brick even at 10% comply with the standard according USEPA (1996) and EPAV(2005a).

Concentration of Copper (Cu)

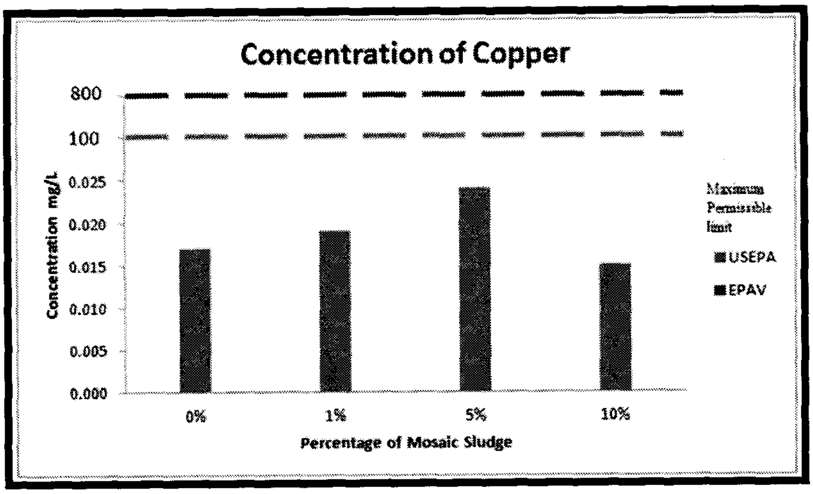


Fig. 3: Concentration of Copper in mosaic sludge brick

Based on Fig. 3, it shows the lowest heavy metals concentration at 10% with average 0.01mg/L of mosaic sludge brick. However, concentrations of Cu were found higher at 1% and 5% of mosaic sludge brick with 0.019mg/L and 0.024mg/L respectively. A study by William (1999)[9] claimed that Copper is often found near mines, industrial settings, landfills and waste disposals. Large of copper may cause liver and kidney damage and even death. According to USEPA (1996) and EPAV(2005a) standard, Copper concentration are detected much lower when incorporated inside the brick compared to the heavy metals concentration limits of 100mg/L and 800mg/L respectively.

Concentration of Cadmium (Cd)

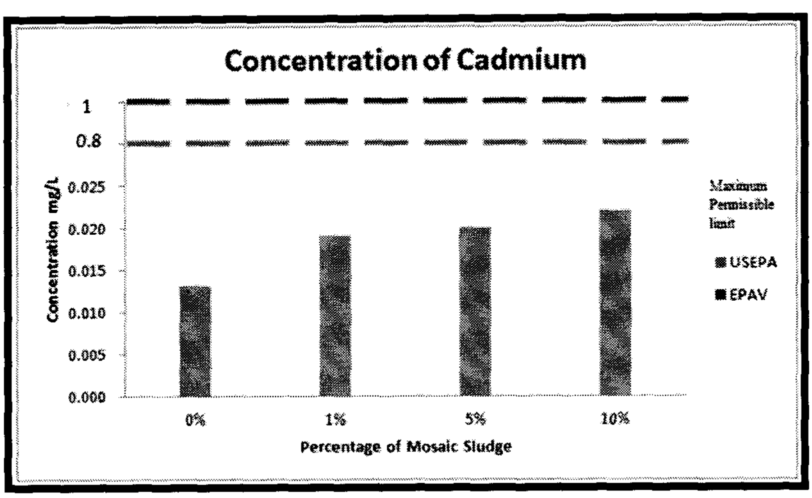


Fig. 4: Concentration of Cadmium in mosaic sludge brick

Refering to Fig. 4, the results show that concentration of Cd with 10% mosaic sludge was the highest with 0.022mg/L. The lowest percentage of Cadmium was obtained for control brick (0.013mg/L) followed by mosaic sludge brick (1%) with average 0.019mg/L. From Wu (2003)[10] research study, Cadmium consists in the industries as an inevitable by Zinc, Plumbum and Copper extraction. For short term, Cadmium could effects on the lung through pulmonary irritation. The Cadmium concentration for all samples tested were comply with standard and below the regulated limits.

Concentration of Iron (Fe)

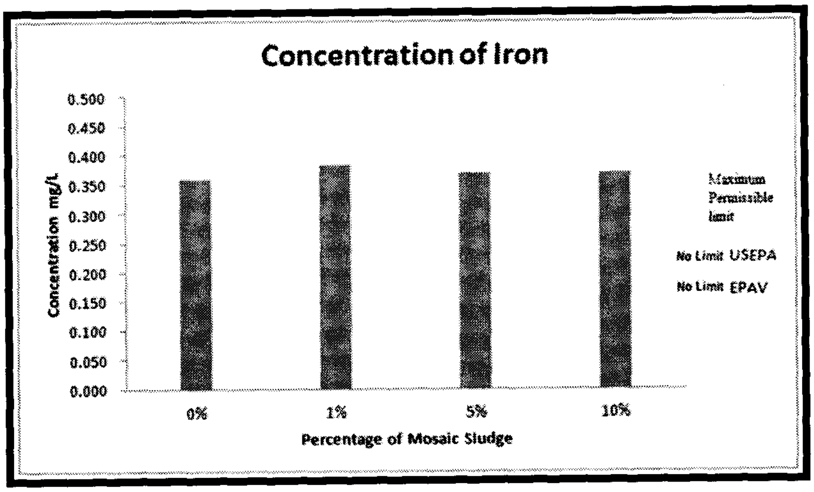


Fig. 5: Concentration of Copper in mosaic sludge brick

According to Fig. 5, the lowest Iron concentration detected at 0% mosaic sludge brick was 0.360mg/L. On the other hand, concentrations of Iron were found similar in mosaic sludge brick at 5% and 10% with 0.369mg/L respectively. Iron is one of the heavy metals used for industries and construction. The common effect of Iron for humans is that it could leads to anemia (Boonsaner, 2006) [8].

Mosaic sludge brick in this tested is insignificant concern since there were no limits for the concentration of heavy metals.

Comparison of heavy metals concentration in mosaic sludge brick

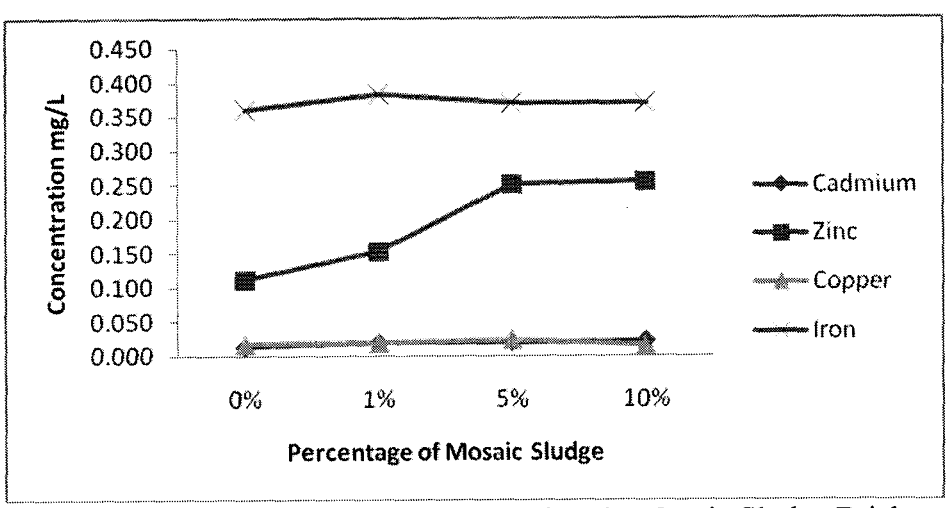


Fig. 6: Concentration of Cu, Cd, Fe and Zn in Mosaic Sludge Brick

Fig. 6 shows comparison of leachability of four heavy metals between Cu, Cd, Fe and Zn in mosaic sludge brick. As a whole, it can be seen that Iron with highest concentration was found in the 1% of mosaic sludge brick with 0.382mg/L followed by 5% and 10% with 0.369mg/L. Secondly, Zinc was detected at 10% with 0.254mg/L and slightly decrease at 5% with average of 0.251mg/L. Cadmium and Copper followed a fairly similar pattern over the 0% to10% of mosaic sludge.

Thus, based on the results shown, concentration of all the four heavy metals in different percentages of mosaic sludge brick were comply with the standard and detected much lower than the acceptable regulatory limits accordance with USEPA, 1996 and EPAV, 2005.

Conclusion

From this study, heavy metals concentration of sludge with different percentages and leachability from mosaic sludge brick were determined. It could be concluded that sludge mosaic could be incorporated up to 10% in fired clay brick as the high concentration of heavy metals in sludge determined become lower once it is utilized into fired clay brick and comply with the regulatory limits according to USEPA(1996) and EPAV(2005a). Therefore, sludge could be an alternative low cost material in brick manufacturing and also providing a disposal method for the mosaic sludge waste.

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