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Lead [Pb2+] removal using Palm Oil Fuel Ash as adsorbent

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Abstract

Palm Oil Fuel Ash (POFA) is a waste generate by the palm oil industry and dumped in the landfill because it doesn't have any economical values. Thus, the study of POFA as a low cost adsorbent has been done to replace the current expensive method of heavy metal removal and to tackle the waste disposal problem. The efficiency of POFA as adsorbent was investigated using batch studies against lead [Pb^{2+}]. The effect of time, pH, initial weight, and temperature has been evaluated. The characterization analysis was done using Scanning Electron Microscope (surface image), BET (surface area and pore volume) and X-Ray Fluorescence (chemical composition). The results shows POFA have great potential as adsorbents for lead [Pb^{2+}] removal.

Key words: Adsorbent, Palm Oil Fuel Ash, Heavy Metal Lead, Batch Studies, Disposal Problem.

1. Introduction

Malaysia produces 14 million tons of palm oil and makes it the largest exporter of palm oil in the world. However, it generates a lot of solid waste in the form of fiber, shell and empty fruit bunches from the palm oil. To tackle the problem, the solid wastes are being use as a fuel in palm oil mill factories as well as to produce steam for generating the electricity. As the results, thousand tons of ash or also known as palm oil fuel ash (POFA) will be generate. POFA is dumped as waste in the landfill and doesn't have any economical value. As the tendency of the government policy to increase the production of palm oil, the amount of POFA will also be increasing and will create detrimental effect to the environment.

Lead is one type of heavy metals that contaminate in almost all waste streams in many industries around the world. Lead is mobilized in wastewater and can enter easily into food web.It is not biodegradable and tends to accumulate in living organisms. The lead will persistencely increase in concentration at every level of foodchain in a phenomenon known as biomagnification. Lead even at low concentrations can cause toxicity and have adverse effects to humans as well as to the environments.

The objective of this study is to produce an economically effective adsorbent from POFA to treat metal contaminating wastewater. The POFA is most desirable because of the availability and at no or very low cost. It will also help in some discharged and disposable problem, because it is clever ways to change the unwanted waste to valuable material.

2.Data and Material

2.1 Adsorbent: Palm Oil Fuel Ash modified with Potassium Iodide (KI)

All of the samples were washed several times with deionized water and heat in the oven for 24 hours at 110 °C. Hundreds grams of each sample was activated by refluxing with 1000 ml of 1M KI at 200 °C for 4 h in a round-bottom flask. The suspension was repeatedly centrifuged and filtered off until free from any residual phosphate and oven dried at 110 °C for 24 hours.

2.2 Adsorbate: Lead nitrate solution

A 10,000 mg/L lead nitrate stock solution was prepared by adding 15.98 g of pure lead nitrate in 1000 mL volumetric flask.

3. Research Methodology

3.1 Characterization of adsorbent

The chemical composition of palm oil fuel was determined using Bruker S4-Explorer X-ray Fluorescence (XRF) spectrometer. The composition of Palm Oil Fuel Ash modified with Potassium Iodide (KI): SiO_2 71.70%, CaO 6.98%, K_2O 5.80%, MgO 4.80%, P_2O_5 3.86%, Fe_2O_3 3.46%, Al_2O_3 2.0%, others 1.4%. The high oxide contents in palm ash give its structure the credibility as a good adsorbents.

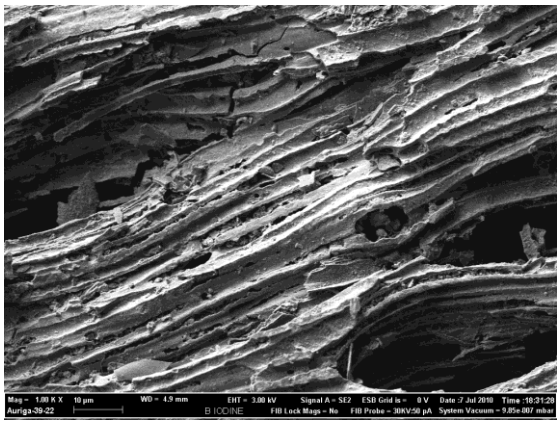

Fig 1 SEM micrograph of Palm Oil Fuel Ash Modified with Potassium Iodide (KI)

Quantachrome autosorb automated gas sorption with autosorb for windows software (AS-3 and As-6 Version 1.23) was used to measure the surface area, pore volume and the pore diameter using Brunaure Emmet Teller (BET) model. The palm oil fuel ash modified with

potassium iodide was found to have surface area 97.81 m^2/g, pore volume 0.06 cc/g and average diameter 26.03 Å.

3.1 Batch equilibrium studies

The experiment was conducted by adding a fixed amount (0.1 g) of Palm Oil Fuel Ash (POFA) treated with Potassium Iodide (KI) into 250 mL plastic bottles. Then 100 mL of diluted lead nitrate solution were added. The bottles were then sealed and placed in shaker and shaken (150 rpm) at room temperature (30 ± 1 °C). The bottles were then removed from the shaker and the solutions were filtered using 0.45 µm membrane filter. The amount of lead left is measured using Atomic Absorption Spectroscopy model Perkin Elmer 400.The amount of adsorption at equilibrium e, qe (mg/g), was calculated by

$$q_e = \frac{(C_0 - C_e)V}{W}$$

Where C_0 and C_e (mg/L) are the liquid-phase concentrations of lead at initial and at equilibrium, V (L) is the volume and W (g) is the mass of adsorbent.

4. Results and Analysis

4.1 Effects of agitation time

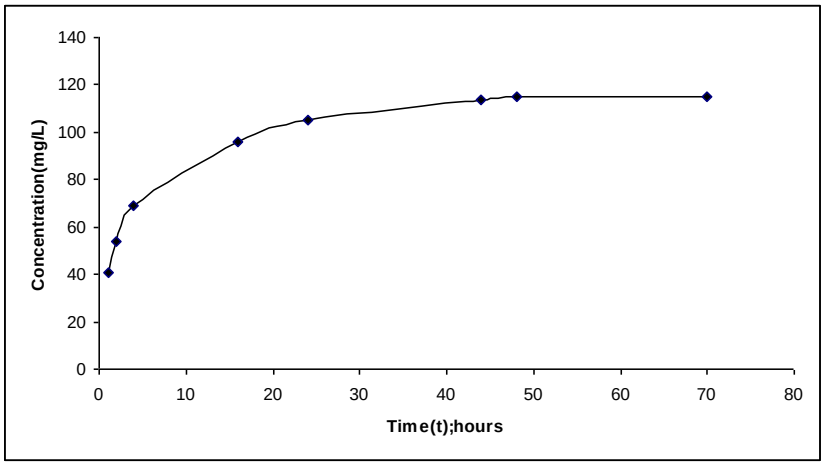

Fig 2. Amount of lead adsorb (in mg/L) as time increasing. Conditions: adsorbent = 0.1g, temperature 30°C.

Figure 2 shows the adsorption capacity of POFA versus the time. The graph shows that the adsorption process start to reach equilibrium at 48 hours. The amount of lead adsorbed at the equilibrium reflects the maximum adsorption capacity of the adsorbent under the operating conditions.

4.2 Effect of pH

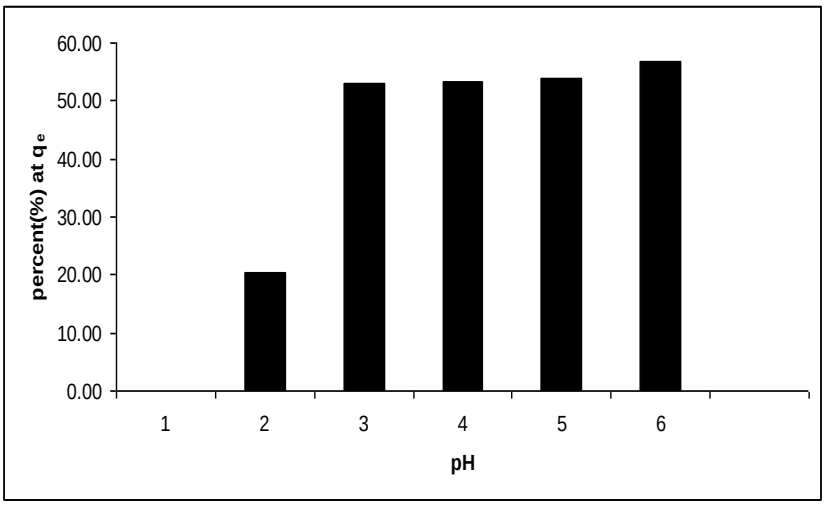

Fig 3. Amount of lead adsorb (percentage) at different initial pH. Conditions: adsorbent = 0.1g, temperature 30^{o}C.

At pH 1, there is zero adsorption and the maximum adsorption is at pH 6. pH 3 till pH5 have adsorption about the same amount. The lead starts to precipitate at pH 7 and above, so no readings were taken as the precipitation will affect the results.

4.3 Effect of initial weight

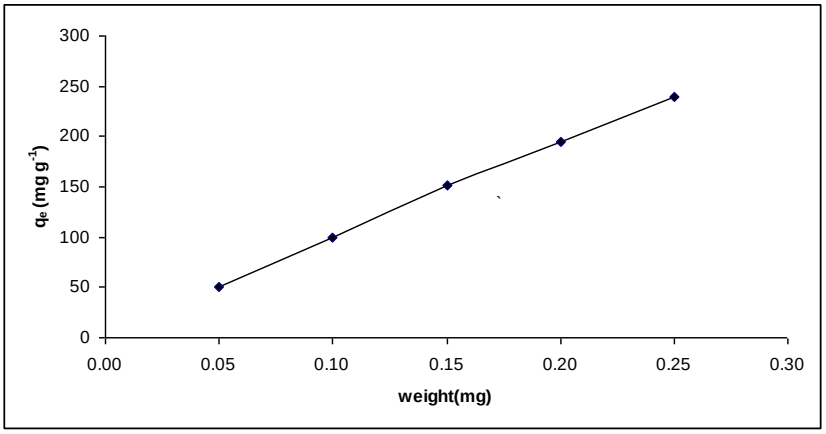

Fig 4 Effect of different initial adsorbent weight Conditions: adsorbent = 0.05 g, 0.10 g, 0.15 g, 0.20 g and 0.25 g. temperature 30^{o}C.

In figure 4, its shows that the amount of lead adsorbs increases as the amount of adsorbent increasing.

4.4 Effect of temperature

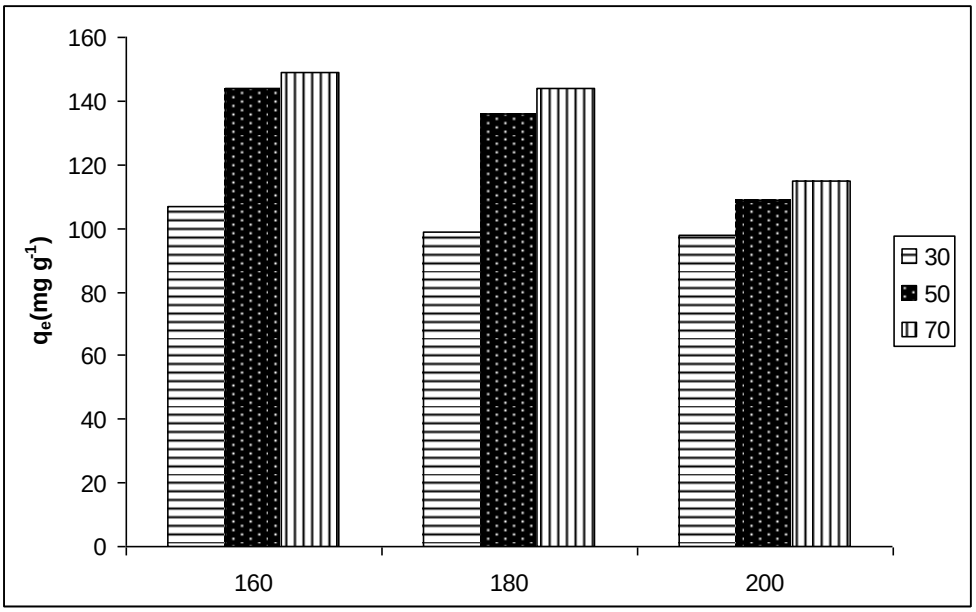

Fig 5 Amount of lead adsorb at different temperature. Conditions: adsorbent = 0.1g, temperature 30°C, 50 °C and 70 °C

The effect of temperature on lead adsorption was studied at 30 °C, 50 °C and 70 °C. Figure 5 indicates that the amount of lead adsorbed at equilibrium increases with increasing temperature at different initial concentration (160 mg/g, 180 mg/g and 200 mg/g). The increases in the equilibrium adsorption of lead with temperature indicate that the adsorption of lead toward modified POFA is an endothermic process. Changing the temperature will change the equilibrium capacity of the adsorbent for a particular adsorbate.

5. Conclusions

The ability of palm oil fuel ash modified with Potassium Iodide to adsorbed lead has been explored. The removal of the lead is depends on time, pH, initial weight, and temperature. Palm oil fuel ash modified with Potassium Iodide shows promising results as a substituted of activated carbon as adsorbent due to the fact has low cost and have capacity to adsorb the pollutant, which in this case is lead [Pb^{2+}]. .

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