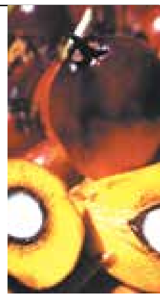

The Use of Boiler Fly Ash for BOD, TSS and Colour Reduction of Palm Oil Mill Effluent

Rusnani Abd Majid* and Hisham Esa*

This study evaluates the use of boiler fly ash obtained from palm oil mill as an adsorbent to treat the palm oil mill effluent (POME) in terms of colour, biological oxygen demand (BOD) and total suspended solid (TSS). The particle size distribution of the boiler fly ash is in a wide range of 20 µm to 2000 µm with moisture content averaging at 1.9%. Results from the adsorption studies showed that boiler fly ash was able to decolourise effluent effectively with less than 45 minutes of treatment. BOD could be reduced by about 62% with fly ash dosage of 200 g litre^{-1}. Maximum reduction of TSS was achieved at 100 g litre^{-1} of fly ash dosage. Results also showed that pH of the filtrate increased with an increase of boiler fly ash.

INTRODUCTION

Environmental quality, such as soil, water and air pollution is becoming a public concern in Malaysia as this can be expected when the country moves towards industrialisation. There are various types of industries that emit pollutants into the air as well as discharge wastewater or effluent into water course or land application. One of the main contributors of organic pollution is from the palm oil industry. With the increase in the number of palm oil mills in Malaysia with a total of 453 mills in 2016, the country's economy has also increased significantly. At the same time, large volume of effluent and solid waste is also being generated.

Besides producing crude palm oil (CPO) and palm kernel as their main products, the mill also generates considerable amounts of by-product/waste such as empty fruit bunches (EFB), palm oil mill effluent (POME), palm fibre and palm shell. About 193 000 t of POME is generated annually from a palm oil mill with capacity of 60 t hr^{-1} of fresh fruit bunches (FFB) (Hamdan *et al.*, 2001). Boiler fly ash is produced in palm oil mill from the burning of fibre and shell in the boiler for producing process steam and power generation. Every t of FFB can produce about 4 kg to 6 kg (0.4% to 0.6%)

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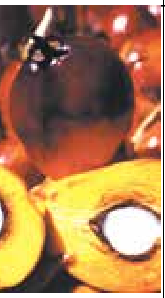


of boiler ash. At present, this fly ash is considered solid waste and disposed off on the land.

Many studies on the adsorption of heavy metals from aqueous solution by fly ash from other sources have been reported (Mathur and Rupainwar, 1988; Weng and Huang, 1994; Ajay *et al.*, 2014). Fly ash is also used in cement and concrete products, structural fills and road construction (Elinwa and Mahmood, 2002; Udoeyo and Dashibil, 2002; Udoeyo *et al.*, 2006).

In view of maximising waste utilisation and with the prospect of Department of Environment (DOE) imposing more stringent BOD limits on palm oil mill, an adsorption method using boiler fly ash was introduced. Thus, this work was conducted to study the effectiveness of using boiler fly ash for the treatment of POME in terms of reducing BOD, TSS and colour.

MATERIALS AND METHOD

Materials

Boiler fly ash and samples of effluent with different concentrations were collected from a palm oil mill. The samples were first dried in an oven at 105°C for 24 hr prior to analysis and experiment. The particle size distribution was determined using a Fritsch sieve shaker by weighing the fractions of the samples collected from each fraction of a series of five sieving trays.

Adsorption Study

The adsorption study on boiler fly ash for POME treatment was carried out by using a stirred method experiment. The experiments were performed by preparing various amounts of fly ash in the range between 15 g and 60 g in a batch of 300 ml wastewater. The fly ash-effluent mixtures were stirred in a temperature-controlled water bath (25°C) at 150 rpm for 30 min. The fly ash was then removed by vacuum filtration with Whatman grade 6 filter paper. Effluent without addition of fly ash was also filtered and used as controled sample. The experiments were carried out in two replications.

Experiments on the effect of contact time to reach adsorption equilibrium were carried out by treating about 45 g (optimum dosage) of fly ash with 300 ml of effluent. The mixtures were stirred and filtered by vacuum filtration with Whatman grade 6 filter paper at various intervals. The filtrates were analysed for BOD, TSS, colour and pH. The BOD and TSS analysis were carried out according to DOE Revised Standard Methods (1985). Colour was measured using a photometer (Model SQ 300, Merck). The pH of the solutions was determined using a pH meter (Model 704, Metrohm, Switzerland).

RESULTS AND DISCUSSION

Boiler Fly Ash

Fly ash from a palm oil mill boiler is greyish to black in colour, contains mainly unburnt carbon. The structures of the fly ash are grainy and flaky with some shell particles also found in the ash. These are expected as palm oil mills used fibres and shell as boiler fuel. The particle size distribution of the fly ash used in this study is presented in *Table 1*. The fly ash contains various particle sizes ranging from less than 20 mm to more than 2000 mm, with more than 50% of the sizes are in the range of 70 mm to 320 mm. The moisture content of the fly ash is 1.9%.

TABLE 1. PARTICLE SIZE DISTRIBUTION OF FLY ASH

Size (µm)	Particle size distribution (%)
-20	0.04
+20 – 70	1.39
+70 – 320	50.42
+320 – 560	20.94
+560 – 2 000	23.50
+2 000	3.86

Adsorption Study

The pH of the filtrates after treatment with various dosages of fly ash are shown in *Figure 1*. Results showed that the pH of POME filtrate increased with the additional of fly ash, and it keeps increasing with the increase of dosages. This is due to the alkaline nature of the fly ash (Behr-Andres and Hutzler, 1994). Weng and Huang (1994) reported that the major alkalinity contributors in fly ash are CaO, K_2O and MgO. Therefore, the amount of fly ash to be used for palm oil mill effluent treatment should not be too high to avoid the waste stream become extremely alkaline.

Table 2 shows the properties of effluent in terms of BOD, colour and TSS before and after treatment with 50g litre^{-1} and 200g litre^{-1} fly ash dosages. The percentages of colour, BOD and TSS reduction with various dosages of fly ash are presented *Figure 2*. The figure shows that the color removal increased with the increased dosage of fly ash. About 42% of colour was removed at 50 g litre^{-1} of fly ash dosage, meanwhile about 70% and 80% of colour removed when the dosages increased to 150 g litre^{-1} and 200 g litre^{-1}, respectively. There was a sharp rise in the percentage of BOD reduction when using 50 g litre^{-1} fly ash and gradually increased with the increase in the fly ash dosage. At 200 g litre^{-1} fly ash dosage, about 62% of BOD was reduced. On the other hand, different trend was observed for TSS, where the value increased during the initial stage and started to decline at 100 g litre^{-1} fly ash dosage. This may be caused by the dispersal of some of the particles of the fly ash into fine particles when stirring at 150 rpm. These fine particles could have been trapped onto the glass fibre disc when conducting TSS analysis.

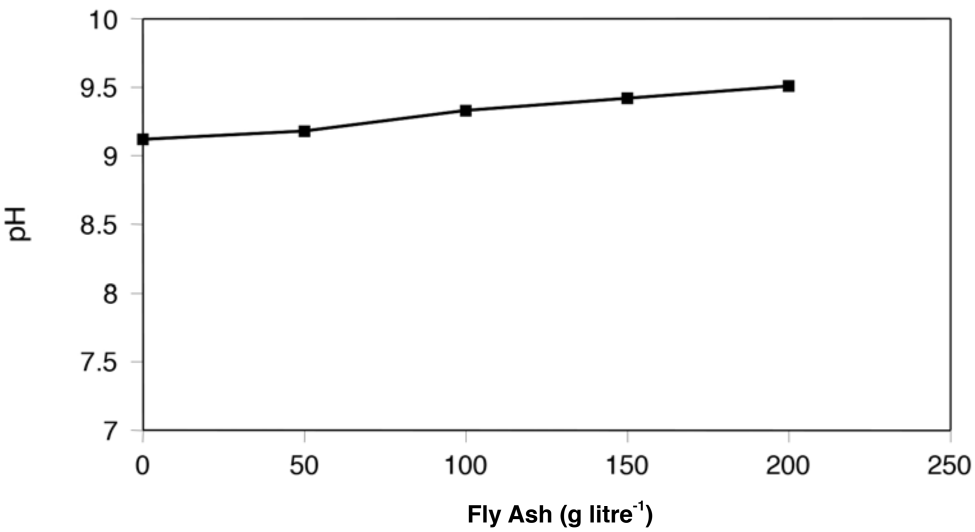
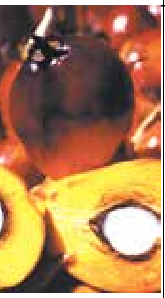


Figure 1. The pH of filtrates treated with various dosages of fly ash.



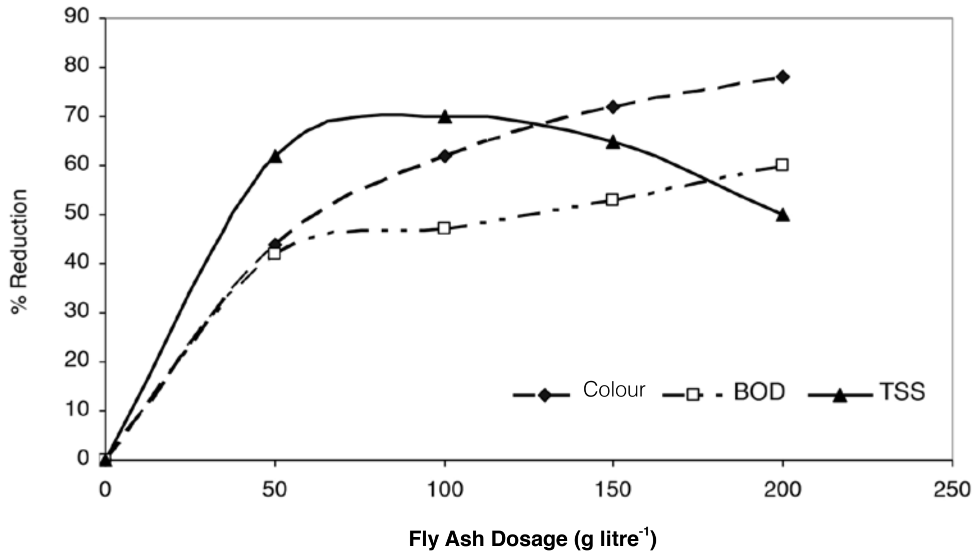


Figure 2. Impurities in filtrates treated with various fly ash dosages.

TABLE 2. BOD, COLOUR AND TSS OF EFFLUENT BEFORE AND AFTER TREATMENT WITH FLY ASH

	BOD (mg litre^{-1})	Colour (Hz)	TSS (mg litre^{-1})
Raw	100	1 606	280
Filtrate after using with:			
50 g litre^{-1} fly ash dosage	58	899	106
200 g litre^{-1} fly ash dosage	40	353	140

Study was further continued in optimising the treatment period using two different types of effluent collected from two different ponds namely concentration 1 and concentration 2. The initial colour of concentrations 1 and 2 were 1096 Hz and 1424 Hz, respectively. *Figure 3* illustrates the colour adsorption by fly ash after stirring continuously for a period of 150 min. In averaging the plots in *Figure 3*, both concentrations gave similar trend in reaching the optimum adsorption of colour at 45 min.

Figures 4 and *5* show the adsorption of BOD and TSS, respectively. Both results showed similar trend of reaching the equilibrium at 45 min, for both effluent concentrations used in the treatment. Higher effluent concentration reduced 38% BOD, but on the other hand higher amount of fly ash give lower TSS reduction. This may be due to the increase of TSS in the treated POME contributed from fly ash.

CONCLUSION

This study has prove that fly ash can be used as an effective renewable material for POME polishing treatment. Fly ash dosage of 200 g litre^{-1} was found to be able to remove nearly 80% and 62% of colour and BOD, respectively. TSS can be reduced effectively at dosage of 100 g litre^{-1} fly ash. The pH value of effluent after treatment increased with an increase of fly ash dosage. The optimum for all the parameters to reach equilibrium was 45 min.

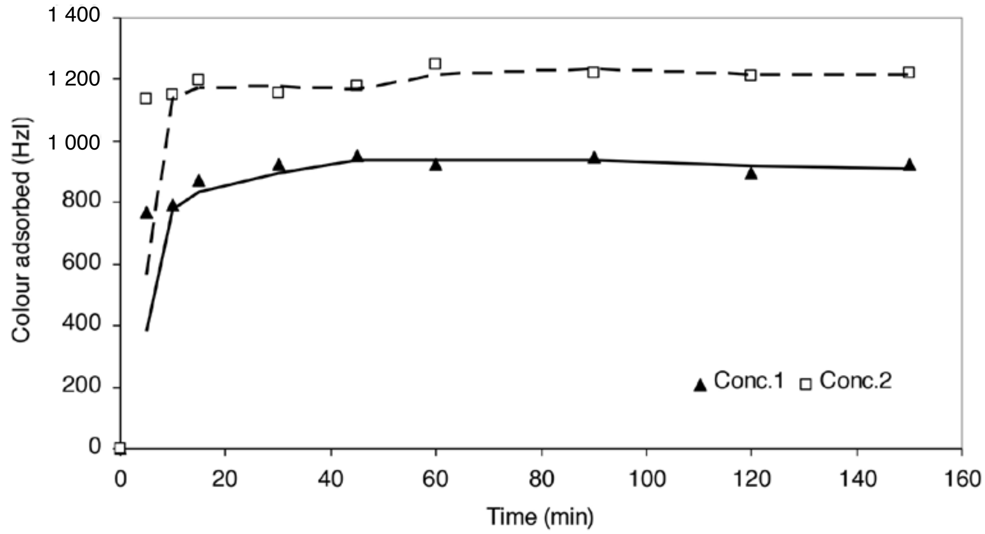


Figure 3. Adsorption of colour by fly ash.

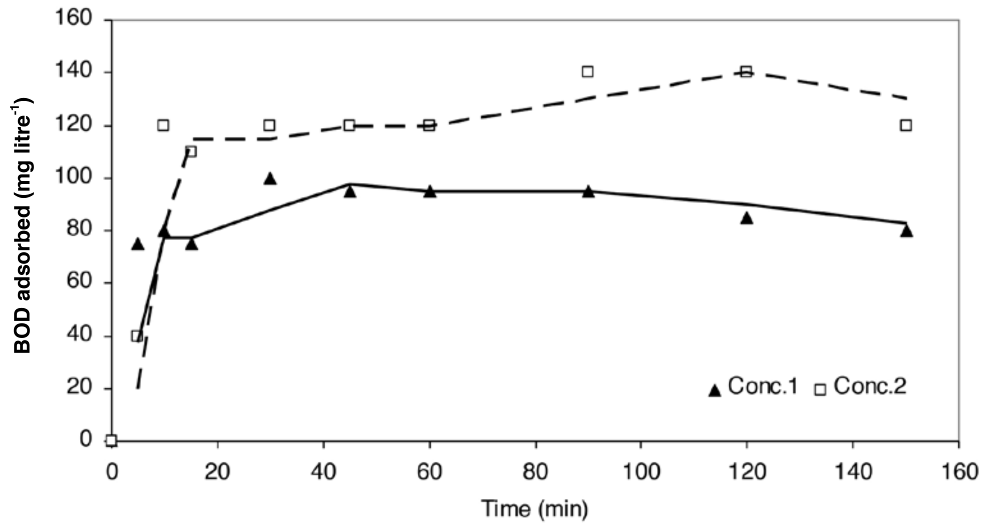


Figure 4. Adsorption of BOD by fly ash.

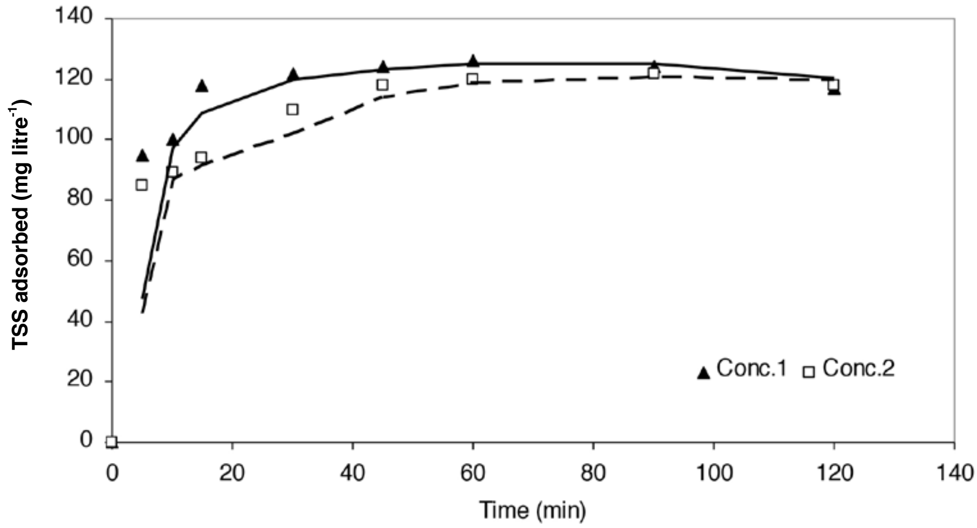


Figure 5. Adsorption of TSS by fly ash.

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