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Removal of Zn(II), Cu(II), Chemical Oxygen Demand (COD) and Colour from Anaerobically Treated Palm Oil Mill Effluent (POME) using Microwave Incinerated Rice Husk Ash (MIRHA)

S.R.M. Kutty[1], S.N.I. Ngatenah[1], N.A. Johan[1], K.A.C. Amat [1]

[1]Department of Civil Engineering, Universiti Teknologi PETRONAS,
31750 Tronoh, Perak, MALAYSIA
E-mail:venomous13@gmail.com

Abstract. Approximately 3 tonnes of POME are produced for every tonne of oil extracted in an oil mill. The POME produced contains high concentration of Chemical Oxygen Demand (COD) and color. The objective of this research was to use microwave incinerated rice husk ash (MIRHA) as an adsorbent in removing Cu(II), Zn(II), COD and color from treated POME wastewater. Rice husk were burned at 800°C temperature to produce MIRHA and soaked overnight in HCl. The effect of various dosages of MIRHA and contact time on removal of Zn(II), Cu(II), COD and colour from treated POME were evaluated by batch studies. The highest Cu(II) removal of 88% was achieved at 50000 mg/L dosage of MIRHA at 12 hr contact time. While for Zn(II), 74% removal was achieved at 50000 mg/L dosage of MIRHA at 18 hr contact time. Optimum removal of COD (41%) and colour (88%) was achieved at 40000 mg/L and 50000 mg/L dosage of MIRHA at 6 hr contact time, respectively. MIRHA proved to be effective in removing Zn(II), Cu(II), COD and colour from POME.

Keyword: palm oil mill effluent (POME), adsorption, MIRHA.

1. Introduction

Malaysia is known as one of the largest producer and exporter of palm oil in the world. Based on index mundi statistic website, Malaysia produced a total distribution of 16.8 million tons in 2005 itself, making it as the biggest production in the world. This economic-generate activity however contributes to an enormous amount of effluent that could pollute the environment if they are not properly treated. For every ton of crude palm oil produced, it is estimated that about 2.5 – 3.5 tons of palm oil mill effluent (POME) is generated (Ahmad *et al*., 2005). POME contains very high concentration of organic matter (COD = 40,000 – 50,000 mg/L) (Zinatizadeh *et al*., 2007). Heavy metals are found to be in excessive amount in the industry and its contamination is commonly discussed amongst the environmentalists as they can cause serious water pollution and threat to the environment. It is necessary to treat metal-contaminated wastewater before discharging into water bodies or natural streams. Heavy metals removal from inorganic effluent can be achieved by conventional treatment process such as chemical precipitation, ion exchange, and electrochemical removal. These processes have significant disadvantages which are for instance, incomplete removal, high-energy requirements, and production of toxic-sludge (Eccles H., 1999). Even though discharge of heavy metals into the environment has decreased in many countries due to stringent legislations, the demand for an economic and environmental friendly method for heavy metals removal still exists (Nomanbhay *et al*., 2005). Thus, adsorption may offer an alternative solution as it has been widely proven to remove heavy metals and residue organics. Most POME is presently treated through anaerobic treatment followed by aerobic ponds. It was observed that it could also be treated using sequencing batch system (Fun C.W *et al*., 2007).

2. Methodology

2.1 Preparation of MIRHA

Rice husk were collected from BERNAS Rice Mill in Seberang Perak, Malaysia. The rice husks were burned at controlled temperature using a microwave incinerator at 800°C to produce microwave incinerated rice husk ask (MIRHA). Then the MIRHA was soaked in hydrochloric acid (HCl) 0.5N for 24 hours and then washed with distilled water thoroughly to remove excessive acid until the water from the residue reached pH 4. Finally, the MIRHA was oven-dried at 105°C for 24 hours.

2.2 Preparation of wastewater sample

The wastewater sample was prepared at 20 mg/L concentration by adding suitable amount of Zinc Chloride ($ZnCl_2$) and Copper Chloride ($CuCl_2$) into 10 L of POME wastewater. The pH of the POME sample was set at pH4 – pH5 without further adjustment during the experiment.

2.3 Effect of dosage of MIRHA and contact time on Zn(II), Cu(II), COD and colour removal

100 mL of prepared wastewater sample was filled into conical flasks. MIRHA was added into each conical flask at various dosages ranging from 10000 mg/L – 50000 mg/L. The samples were then agitated using the orbital shaker at various contact times of 1, 2, 3, 4, 5, 6, 12 and 18 hr. After end of each contact time, the samples were filtered and the supernatant was analyzed using Atomic Adsorption Spectrophotometer (SHIMADZU AA 6800) for residual Zn(II) and Cu(II), COD and colour concentration using DR 2800 Spectrophotometer.

3. Results and Discussion

3.1 Characteristics of POME

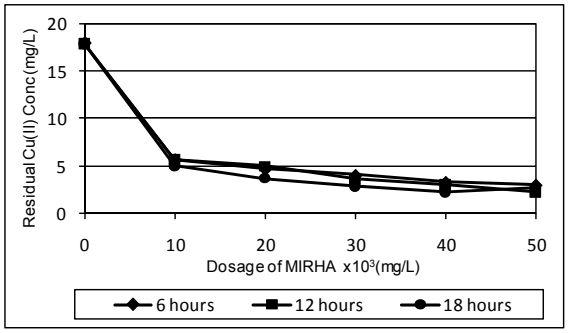
The temperature of POME was 80-90ºC with acidic behavior (pH3.8 - 4.5). The COD of POME was found be in the range 40000-50000 mg/L. The effluent was considered a non-toxic wastewater as no chemical was added in the oil extraction process. The raw POME was high in degradable organic matter, which most probably caused by the presence of unrecovered palm oil. The characteristic of POME was presented in Table 1 below. After anaerobic treatment at the oil palm mill, the COD and colour, was approximately 600 mg/L and 9000 PtCo, respectively.

Table 1: Characteristics of POME

Parameter	POME
pH	3.8 – 4.5
Biochemical Oxygen Demand (BOD)	30,000 mg/L
Chemical Oxygen Demand (COD)	50,000 mg/L
Suspended Solids	59350 mg/L
Color	9250 PtCo

3.2 Effect of Dosage of MIRHA on Cu(II) and Zn(II) removal from treated POME

The effect of variation of MIRHA dosages on adsorption of Cu(II) and Zn(II) were conducted at various contact times. Figure 1 below shows the residual concentration of Zn(II) and Cu(II) at various dosage of MIRHA for 6, 12 and 18 hr. It can be observed that removal of Cu(II) and Zn(II) from treated POME increased with increase in dosages of MIRHA. It was observed that highest adsorption of Cu(II) and Zn(II) were achieved at 50000 mg/L dosage of MIRHA. At this dosage, the highest removal of Cu(II) and Zn(II) was approximately 88% and 74%, at contact times of 12 hr and 18 hr, respectively. Not many variations were observed with increased contact times beyond 6 hours. This was expected due to the fact that higher dosage of adsorbent provides more surface area, thus increases the availability of exchangeable sites for the ions (Nomanbhay *et al*., 2005).



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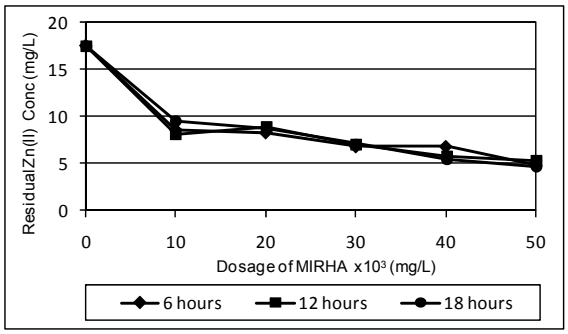
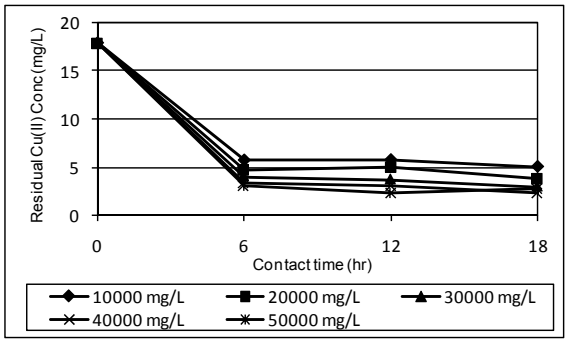


(b)

Figure 1: Residual (a) Cu(II) and (b) Zn(II) concentration at various dosages of MIRHA for 6, 12 and 18 hr.

3.3 Effect of contact time on Cu(II) and Zn(II) removal from treated POME

The effect of variation contact times in removing Cu(II) and Zn(II) were evaluated at various dosages of MIRHA. Residual Cu(II) and Zn(II) concentration vs. time was plotted in Figure 2 It can be observed that approximately 88% of Cu(II) was removed from treated POME wastewater at 12hr contact time and 50000 mg/L dosage of MIRHA. However, for Zn(II) contact time of 18 hr was required to achieve removal of approximately 71% at optimum dosage of MIRHA of 50000 mg/L. It can be concluded that increase in contact time resulted in the increase of metal removal efficiency. These results indicate that the extent of adsorption increased rapidly in the initial stage but slowed in the later stages until it reached equilibrium (Belgin. B., 2002, Homagai P. L., 2009).



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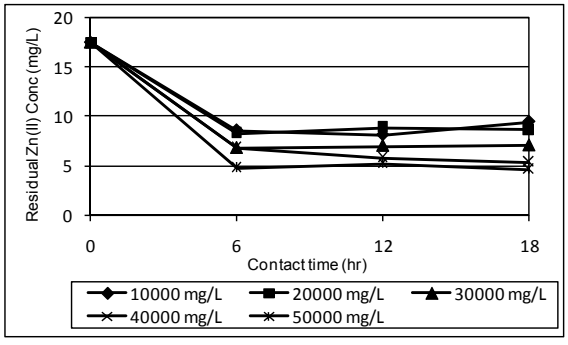
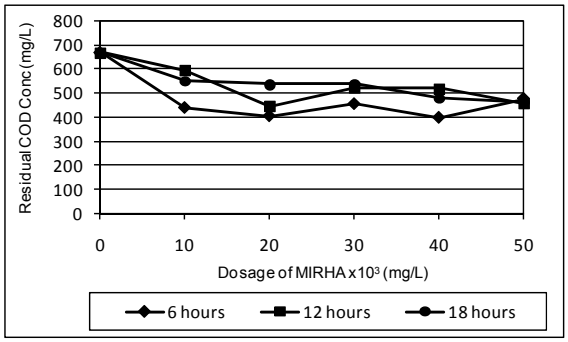


(b)

Figure 2: Residual (a) Cu(II) and (b) Zn(II) concentration at various contact time and dosages of MIRHA.

3.4 Effect of Dosage of MIRHA on COD and colour removal from treated POME

Figure 3 show the residual COD and colour concentration at various dosages of MIRHA at 6, 12 and 18 hr. It can be observed that the highest removal of COD (41%) was achieved at 6 hr when 40000 mg/L dosage of MIRHA was used. Increasing the contact time seemed to increase residual COD. The increase maybe contributed to leaching of COD from MIRHA. Whilst for colour, approximately 88% removal of colour was obtained at contact time of 6 hr with 50000 mg/L dosage of MIRHA. Above 10000 mg/L of MIRHA, not much difference in removal of colour was obtained at higher contact times.



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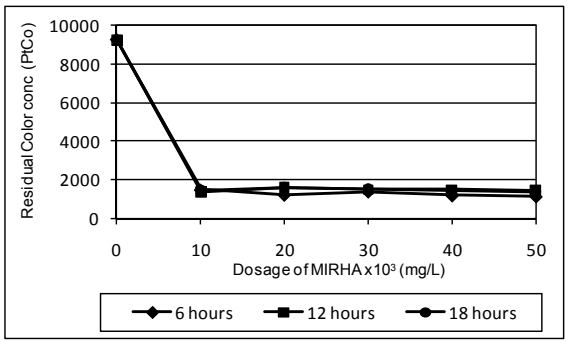
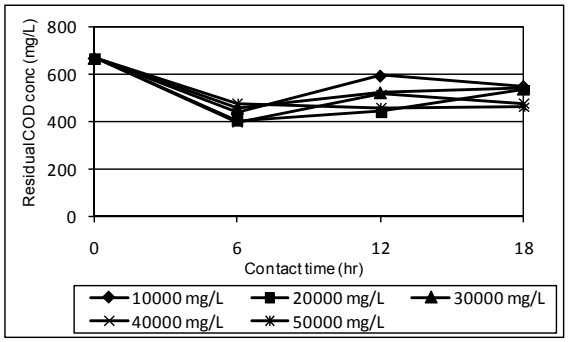


(b)

Figure 3: Residual (a) COD and (b) colour concentration at various dosages of MIRHA for 6, 12 and 18 hr.

3.5 Effect of contact time on COD and colour removal from treated POME

The effect of varying contact times on COD and colour removal were evaluated at various contact time and dosages of MIRHA. Figure 4 show the residual COD and colour concentration at various contact time and dosages of MIRHA. It was observed that almost 40% of COD and 88% or colour was removed from POME wastewater at optimum contact time of 6 hr. Longer contact time above 6 hours and higher dosages above 10000 mg/L also did not result in further removal of colour.



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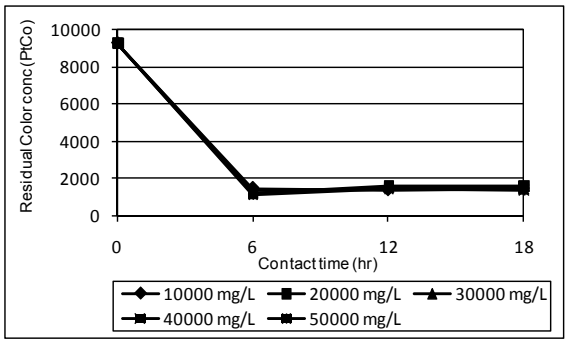

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Figure 4: Residual (a) COD and (b) colour concentration at various contact time and dosages of MIRHA

4. Conclusion

In this study, MIRHA was investigated for its effectiveness in removing Cu(II), Zn(II), COD and Color from treated POME wastewater with approximately 88%, 74%, 41%, and 88% removal, respectively. The percentage removals were increased as dosage of MIRHA and contact time was increased. MIRHA proved to be plausible in removing all the tested parameters and therefore stand a big possibility to be commercialized as an alternative adsorbent.

5. Acknowledgement

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