

Chemical Treatment of Palm Oil Mill Effluent (POME) from Aerated Pond

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Abstract— The production of palm oil results in the generation of huge quantities of polluting wastewater commonly known as Palm Oil Mill Effluent (POME). POME is a thick brownish liquid that contains high amount of total solids, oil and grease, chemical oxidation demand (COD), biochemical oxygen demand (BOD), and if not properly treated, can disrupt the natural ecosystem and pose a serious threat to human health. However, with the stringent regulations on discharge of waste into the environment, there is need to retrofit the existing biological system by adding tertiary treatment in form of coagulation to remove contaminants in order to meet the current discharge regulations. This paper compares the use of coagulants ferric chloride and aluminium sulphate to reduce turbidity that is associated with the effluent. Series of batch coagulation and flocculation processes with ferric chloride and aluminum sulphate under different conditions, i.e. dosage and pH were conducted in order to determine their optimum conditions. Polyacrylamide was used as coagulant aid and its optimum dose was also determined. The result of the coagulation process showed that ferric chloride gave a better reduction of turbidity at dosage of 100mg/L, pH of 8 and with polyacrylamide (coagulant aid) dose of 100mg/L than alum.

Keywords-POME, Chemical treatment, Jar test, coagulation

I. INTRODUCTION

There has been increasing concern for environmental risk of industrial activities associated with extraction, food processing mining, refining etc. These industrial activities have increased the threat of pollution to the environment and subsequently concomitant discharged into the environment creates major ecological problems throughout the world. One of the industrial activities which generate highly polluting waste is palm oil extraction. POME is a highly colloidal suspension of 95- 96% water, 0.6-0.7% oil and 4-5% total solids including 2-4% suspended solids originating from the mixture of a sterilizer condensate, separator sludge and hydrocyclone wastewater. It is hot (80-90oC) and very acidic [1]. POME is a highly voluminous liquid wastes which are non toxic, have an unpleasant smell and if not properly treated will disrupt the natural ecosystem and pose a serious threat to human health. Palm oil is a very important and essential commodity in Malaysia; it contributes immensely to the economy. Presently, Malaysia is currently one of the largest producers of palm oil exporting to over 150 countries around the world. Palm oil cultivation is currently around 4.48 million hectares and

generates revenue of RM 65.2 billion. Thus it is estimated that for 1 tonne of crude palm oil produced, about 5-7.5 tonnes of water is required and more than 50% turn out as POME. Thus, the adverse environmental impact from palm oil effluent cannot be neglected [2]. The biological treatment is currently used in treating POME and effluent discharged still contains high organic loads. Thus, the use of coagulation can be used to reduce the high pollutants that are still present in POME. Currently, there are several chemicals that been conventionally and commercially used as coagulant in the water and wastewater treatment. Aluminium and iron salts are widely used as coagulants in water and wastewater treatment. Each of the coagulant affects the destabilization degree of the colloid particles differently. They are effective in removing wide range of impurities from water, including colloidal particles and as well as dissolved organic substances. The higher the valance of the counter-ion, the more its destabilizing effect and lesser dose needed for coagulation. The formation of the hydrolytic products formed from metal salt coagulants occurred in a very short time and they are readily absorbed onto the colloid particles and then cause destabilization of their electrical charge. Apart of that, uniform pH of the wastewater during the coagulation process is essential for the enhancement of hydrolytic reaction [3]. Flocculation is conducted under conditions of lower mixing intensity to prevent shear and degradation of the growing floc particles. Flocculation is the transport steps that bring the collisions between destabilized colloid particles need to form the larger particles than those obtained by coagulation and can be removed readily by settling and then filtration [3]. Polyacrylamide was used as coagulant aid which aid in settling the flocs readily. The objective of this paper is to ascertain which coagulants either ferric chloride or aluminium sulphate have the potential to form a larger floc and higher removal of turbidity. It is anticipated that the data obtained would help to identify the better coagulant which would be useful in treating POME from the aerated lagoon to meet the current regulation discharge. Also the optimum coagulant dose and pH were determined for both ferric chloride and aluminium sulphate. The optimum polyacrylamide dose was also determined in this study.

II. MATERIALS AND METHODS

A. Materials

The POME was collected from local palm oil mill and stored in fridge at 40C to prevent biological activity. The effluent was taken from the aerated lagoon of the biological treatment system. The POME samples collected showed high levels of contaminants as tabulated in Table 1.

Table 1: Characteristic of palm oil mill effluent (POME) obtained from local mill

PARAMETERS	POME FROM POND
pH	8.24
Temperature	30°C
COD	5610mg/l
VSS	2840mg/l
Turbidity	2590NTU
TS	8580mg/l
TSS	4314mg/l
TDS	4266mg/l

B. Coagulants and Coagulant aid Used s

The chemical properties and the physical properties for alum and ferric chloride coagulants used for the coagulation process are tabulated in Table 2 and the physical properties of the polyacrylamide coagulant aid used in the flocculation process is also tabulated in Table 2.

Table 2: Coagulants and coagulant aid used

Coagulants Used	Formula	Molecular Weight
Aluminium Sulphate	$Al_2(SO_4)_3 \cdot 16H_2O$	598.4
Ferric Chloride	$FeCl_3$	162.2
Type	Name	Molecular Weight
Anionic	Polyacrylamide	104- 107

C. Jar Test Procedure

The jar test procedures were conducted in three stages. In the first stage, the optimum coagulant was determined. A volume of 500 ml of biologically treated POME was added to each of six beakers with ferric chloride and alum solutions at different

dose (50 to 300mg/l) added into each beaker. For the first set of runs, the pH value was set at 9 which is the original pH of the sample. The water was rapidly mixed at approximately 110rpm for two minutes. This was followed by slow mixing at 30rpm for 25 minutes for flocculation to take place [4]. At the end of the mixing period, the floc was allowed to settle for about 30 minutes. The supernatant was collected and turbidity was measured. From the result, the optimum dose was determined. Then in the second stage, the pH was varied from 6 to 11 for ferric chloride salt and from 5.5 to 8 for alum. The optimum coagulation dose obtained earlier was added to each beaker while varying the pH. The adjustment of pH was done by adding either 1M hydrochloric acid (HCl) or 1M sodium hydroxide (NaOH) into the sample solution. The same procedure was followed as in the first step. Also, the turbidity was used in determining the one with the best result. Finally, in the last stage Polyacrylamide was added. This acted as a coagulant aid to help good formation of floc and to assist in rapid settling. Using the optimum dose for pH and coagulant dose earlier, various doses ranging from 50mg/l-300mg/l were added in each beaker to determine the optimum coagulant aid.

D. Analytical Analysis

Turbidity was measured using the nephelometric method with a 2100P HACH portable turbidimeter. The measurement is based on the light-transmitting properties of water. The percentage reduction for turbidity in the coagulation processes was calculated by using equation 1.

$$R_{coagulation} = \left(1 - \frac{T_f}{T_i}\right) \times 100 \quad (1)$$

where $R_{coagulation}$ is the percentage reduction for the coagulation process, T_f is the turbidity obtained after coagulation process and T_i is the initial concentration of POME from the aerated lagoon.

III. RESULTS AND DISCUSSIONS

Optimum Coagulant Dose

Fig. 1 shows the optimum ferric chloride and alum dose. It is shown that at 50mg/L dose the turbidity was high as a result of insufficient ferric chloride present which could not bring about complete charge neutralization of the colloidal particles.

For ferric chloride, at dosage 100mg/L of coagulant, the turbidity was 10 NTU. Beyond 100mg/L, the turbidity increases with increase in ferric chloride dosage. This could be as a result of over dose which brought about reversal destabilization (restabilization) of the particles. When the coagulant exceeds its optimum charges neutralization, the overdose will cause charge reversal, particle stability and corresponding higher residual turbidity. Also, for aluminium sulphate, similar findings were also observed with dosage of 50mg/L in which turbidity was high as a result of insufficient alum present which could not bring about complete charge neutralization of the colloidal particles. The optimum dose occurred at 150mg/L. The percentage turbidity removal for both coagulants are also showed in Fig. 2 and from the results, it can be seen that ferric chloride has higher removal efficiency

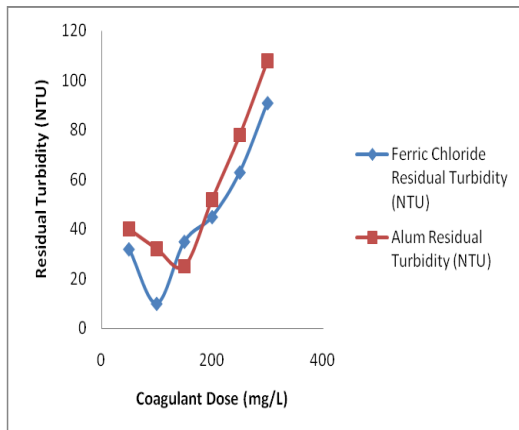


Fig 1: Residual Turbidity Removal of coagulants

than Alum. This could be as a result of higher molecular weight of iron ions and higher active metal concentration of the iron ions [8].

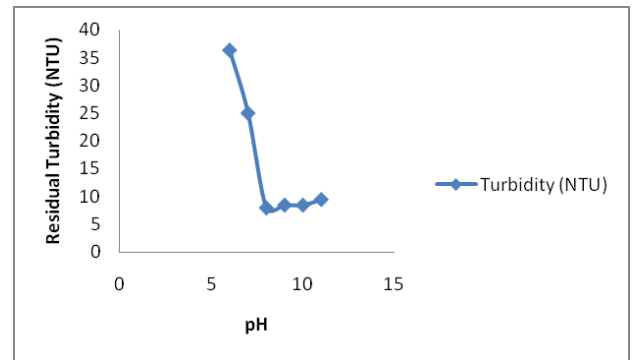


Fig 3: Turbidity values at different pH for ferric chloride

turbidity for ferric chloride is stronger than alum and this was also confirmed in study carried out in [4].

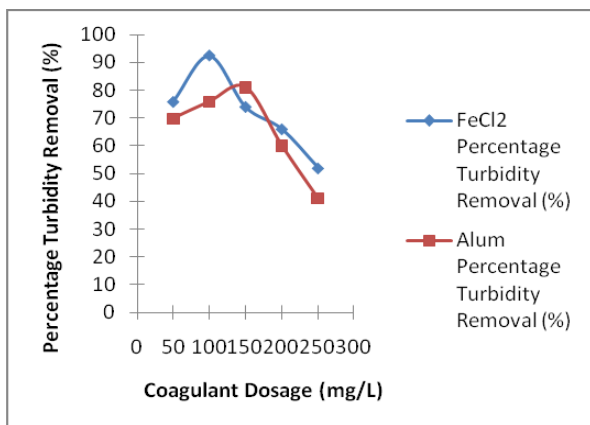


Fig 2: Percentage Turbidity Removal of coagulants

D. Optimum pH range for ferric chloride and alum

Turbidity values after coagulation with ferric chloride at varying pH is shown in Figure 3. From the results, the optimum pH was obtained at 8. Beyond pH of 8, the turbidity values obtained showed little differences. This could be as a result of high alkalinity which favours sedimentation and hence lower turbidity [4,8]. For aluminium sulphate, findings from earlier studies showed that aluminium sulphate performs better in pH range of 5.5-8 [5,6,7,8,9]. The results are shown in Figure 4 and from the results the optimum pH for alum was found at 6. It can also be observed that the turbidity increases as the pH increases. This could be as a result of increase in solubility of alum at higher pH. At lower pH, more accelerated corrosion rate occurs thus, increase in turbidity is observed [8, 10]. Thus, effect of increasing pH value on reduction of

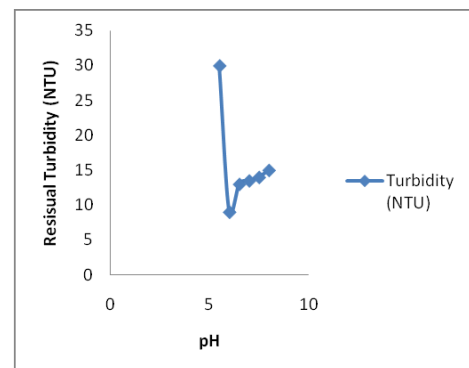


Fig 4: Turbidity values at different pH for alum

E. Optimum Coagulant aid Dose

Coagulant aid is used for better coagulation and more decrease in turbidity. Here, a polymeric (anionic) coagulant is used i.e. polyacrylamide. This type of coagulant aid, in addition to neutralize the positive charges in water, causes the formation of flocs more quickly and increases the rate of sedimentation by bridging and connecting the already-formed flocs so that with the network formed during sedimentation they take other tiny particles which couldn't form flocs inside them and make them sediment along with themselves [4,5, 6, 7, 11]. In this stage, six beakers with different coagulant aid dosage were tested at optimum ferric chloride dose of 100mg/l and optimum pH of 8. The coagulant aid used in this research

was anionic polyacrylamide with doses ranging from 50mg/l to 300mg/l was added to each to the beakers during the slow mixing which lasted for 25 minutes. Also, the same step as described above was done to aluminium sulphate at optimum dosage of 150mg/l and optimum pH of 6. The results for optimum coagulant aid dose for both ferric chloride and alum are shown in fig 5 and from the results shown in fig 5, adding coagulant aid was very influential in decreasing turbidity and also the rate of reduction in turbidity with coagulant aid is much more than its rate when only coagulant is used. Thus, the optimum coagulant aid dose for ferric chloride is 100mg/L and for alum is 150mg/l.

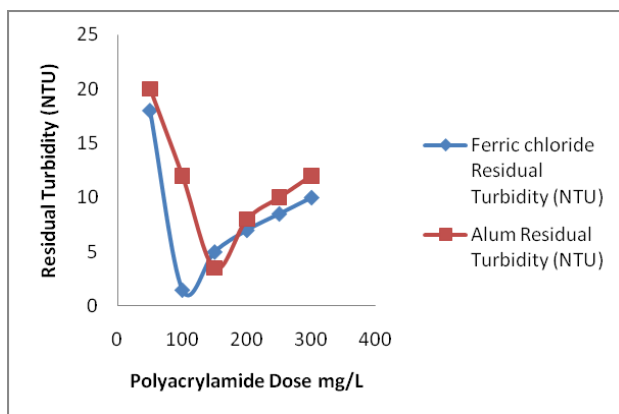


Fig 5: Turbidity values obtained from Jar Test with different dose of polyacrylamide

IV. CONCLUSIONS

This study has demonstrated that coagulation with aluminium sulphate and ferric chloride is an effective way to treat POME from aerated lagoon by reducing the turbidity. The optimum dose for ferric chloride and aluminium sulphate was carried out in this study. Also, the optimum pH range for alum and ferric chloride was also determined in this study. The optimum dose for polyacrylamide was determined in this study. Ferric chloride produced better results than aluminium sulphate in decreasing the turbidity. Polyacrylamide was used as coagulant aid to further reduce turbidity. Polyacrylamide with ferric chloride has more effect in reducing turbidity in comparison to alum. Coagulation using ferric chloride with polyacrylamide gave high turbidity reductions from 132.4 Nephelometric Turbidity Unit (NTU) to 2 NTU. Thus, in this study, ferric chloride at 100mg/L, pH of 8 and with polyacrylamide (coagulant aid) dose of 100mg/L, was used in treating POME from the aerated lagoon.

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