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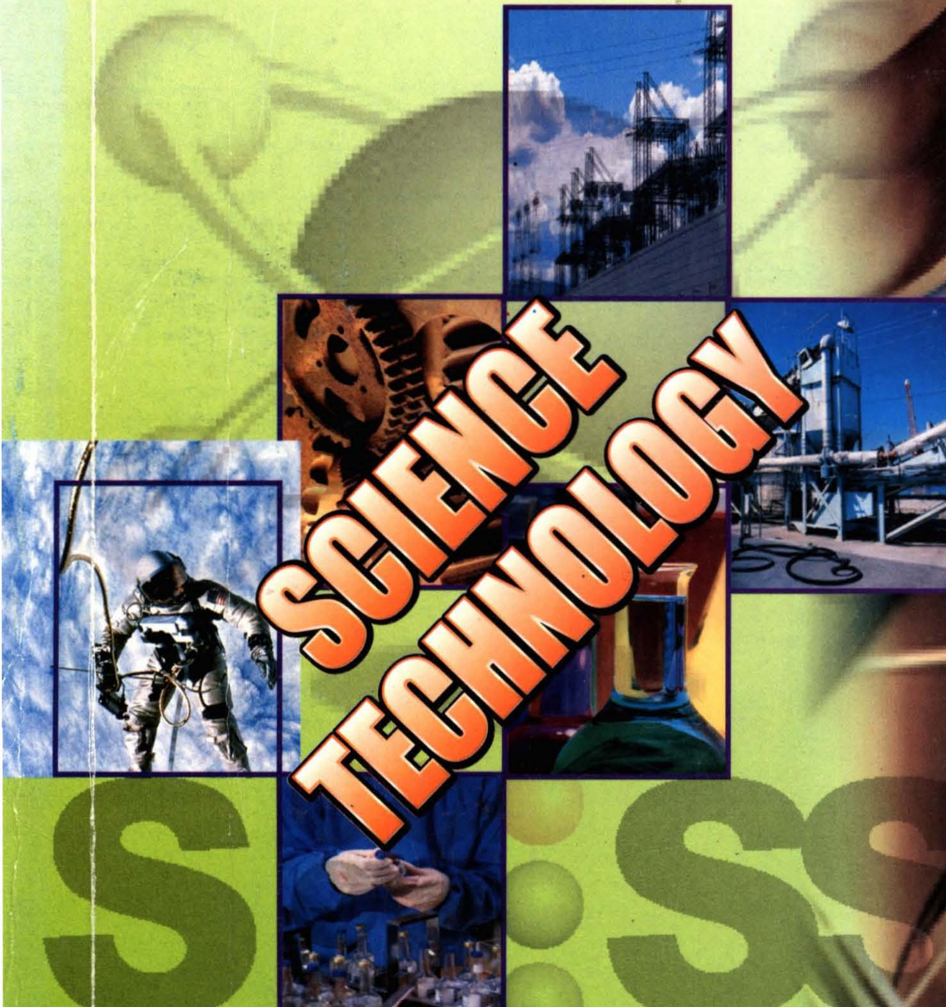

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Further Treatment of Palm Oil Mill Effluent using Physical Chemical Treatment using Various Coagulants and Recycled Iron Sludge

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ABSTRACT

Palm Oil Mill Effluent (POME) is known to cause serious environmental hazards due to its high biological and chemical oxygen demand if disposed without treatment. Moreover, the processing of palm fruit causes POME to have fibre and husk causing high level of total suspended solids (TSS) and turbidity. This work focused on the reduction of chemical oxygen demand (COD), turbidity and TSS based on physical-chemical treatment. Effluent samples were taken from a near-by palm oil mill. Aluminium sulphate and ferric chloride were utilized as coagulants. The experimental results showed that pH decreased with coagulant dosage due to acid production. The optimum dosage for alum was found to be 6000mg/L at pH range 6 – 6.5. The results had shown 99% reduction in turbidity, 91.5% reduction COD and 60% reduction for TSS. Whereas, the optimum dosage for ferric chloride was found to be 2600 mg/L with pH 5 giving 99% reduction in turbidity, 95% and 97% reduction in COD and TSS, respectively.Ferric chloride was found to be the more effective coagulant. Further studies were conducted using recycled iron sludge (RIS) from Kelantan water treatment plant and it was revealed that RIS had produced comparable results with ferric chloride and alum showing 86% reduction in COD with the optimal dosage of 800 mg/l which was less than the dosage required for alum and ferric chloride.

Keywords: *POME, COD, TSS, Recycled iron sludge*

Introduction

Generally, effluent from palm oil mill is acidic in nature and has high biological oxygen demand (BOD) and chemical oxygen demand (COD). The effluent treatment system needs to be efficient, rapid and should be simple to be attractive cost-wise (Zulkifli 1999). In Malaysia, crude palm oil (CPO) industry was known to be one of the worst sources of water pollution since 1975. To counter this, effluent control in the palm oil industry was set through a system of licensing within the Environmental Quality Regulations 1977 (Amendment 1982). A survey on the licensing system conducted by PORIM and the Rubber Research Institute of Malaysia in 1980-81 revealed that 90% of the mills surveyed discharged POME with a BOD concentration below the standard at that time (500 mg/l) but also showed that standards on COD, total solids and organic nitrogen have been proven difficult to achieve. In concession to this, the Department of Environment (DOE) eliminated the standards on COD while the BOD standard has been lowered to 250 mg/l. Due to the eliminations, by the end of 1982, 80% of the palm oil mills complied with the standard. (Khalid 1994) However, this new standard no longer has the limit for COD and total solids. As for turbidity, so far there has never been a limit for POME.

The characteristics of raw POME are shown in Table 1.

Table 1: Characteristic of Palm Oil Effluent

Parameter	Concentration*
pH	4.7
Temperature	80 – 90 (°C)
Oil and grease	4000 mg/l
BOD	25000 mg/l
COD	50000 mg/l
Total solids	40500 mg/l
Suspended solids	18000 mg/l
Total volatile solids	34000 mg/l
Ammoniacal nitrogen	35 mg/l
Total nitrogen	750 mg/l
Phosphorus	180 mg/l
Potassium	2270 mg/l
Magnesium	615 mg/l
Iron	46.5 mg/l
Manganese	2.0 mg/l
Zinc	2.3 mg/l

Under the licensing procedure, standards are set for the POME prior to discharge. A common discharge standard for POME is as in Table 2. However, these limits may vary depending on what is stated on the license (GTZ 1997).

Table 2: Parameter Limits for Wastewater Discharge of POME

Parameter	Discharge Standards
*BOD	<100 mg/l
Suspended solids	<400 mg/l
Oil and grease	<50 mg/l
Ammoniacal nitrogen	<150 mg/l
Total nitrogen	<200 mg/l
pH	5.0 – 9.0
Temperature	45°C

* BOD sample incubated for 3 days at 30°C

Physical chemical treatment requires chemical dosages and application rates have to be determined by bench or pilot-scale tests. This treatment is more suitable for industrial wastewater instead of municipal wastewater. This method is less popular in treatment of municipal wastewater due to its lack of consistency in meeting discharge requirements and high cost of chemical. Aside from that it requires handling and disposal of large volume of sludge resulting from the addition of chemical and other operating problems (Metcalf and Eddy 2003). This research evaluated further removal of COD, TSS and turbidity using physical chemical treatment using alum, ferric chloride and RIS as coagulant while all samples were from a local palm oil processing industry.

Methodology

This study includes further COD, turbidity and TSS removal for POME using the physical chemical treatment method. POME samples were taken from the maturation pond of a local palm oil mill. During the sampling, the measured flow rate of effluent discharge was approximately 0.25 m^3/s. Jar tests were conducted which simulated the physical chemical treatment processes that included mixing, flocculation and settling. In the jar test POME samples were placed in six beakers where the samples were mixed rapidly with different dosages of coagulants for one minutes at 150 rpm. After that, it was mixed slowly at about 25 rpm for fifteen minutes for the formation of flocs and then the flocs were allowed to settle for about half hour.
Supernatant of the settled samples were then tested for its COD, TSS and turbidity. In the COD test, the samples were diluted where necessary. They were heated for two hours at 150 °C. For the TSS test, about 25 ml of the sample (diluted where required) was taken and standard TSS test was conducted. These tests were repeated with different dosages and different coagulants for the jar test throughout this study. Turbidity of the samples was determined using Turbidimeter measured in NTU. pH of the samples was checked at every step.

Results and Discussion

The characteristics of the raw POME sample was tested and the results averaged 16358 mg/l for total COD, 685 NTU for turbidity and 416 mg/l of TSS with the pH at 8.7.

Use of Aluminium Sulphate (Alum) as a Coagulant

After the dosage of 6000 mg/l of alum, the final COD reading did not differ much even by dosage increment. Thus, the optimal dosage was taken to be at 6000 mg/l of alum with pH in the range of 6 to 6.5.

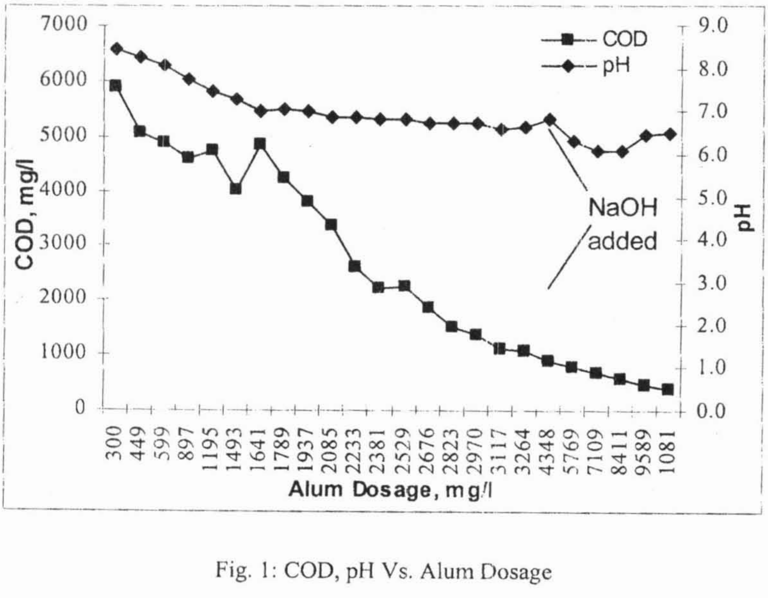

Fig. 1: COD, pH Vs. Alum Dosage

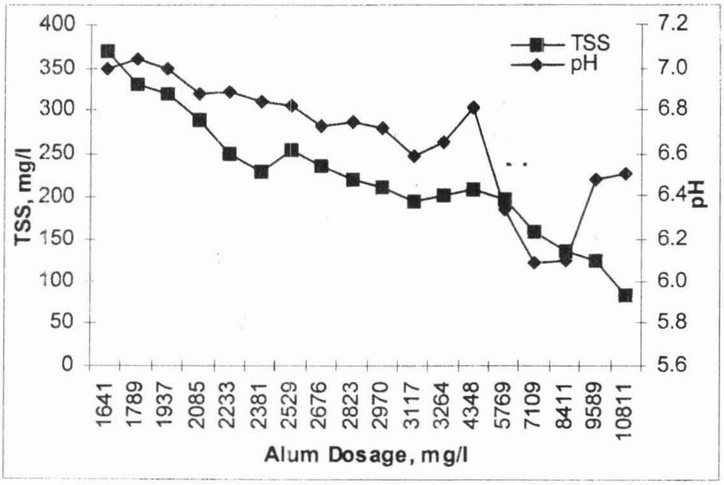

Fig. 2: TSS, pH Vs Alum Dosage

For TSS, the dosage required to lower the value below 100 mg/l was too high and uneconomical. As a compromise, a dosage of 4000 mg/l at pH 6.4 was taken as the optimal condition where the final TSS was 200 mg/l.
The optimal condition for turbidity removal was at pH 6 with an alum dosage of 6000 mg/l with final turbidity below 30 NTU. Although the turbdity could be reduced further with increment of alum dosage but turbidity of less than 50 NTU was considered to be sufficient. Beyond alum dosage of 6000 mg/l, final turbidity did not show any substantial reduction.

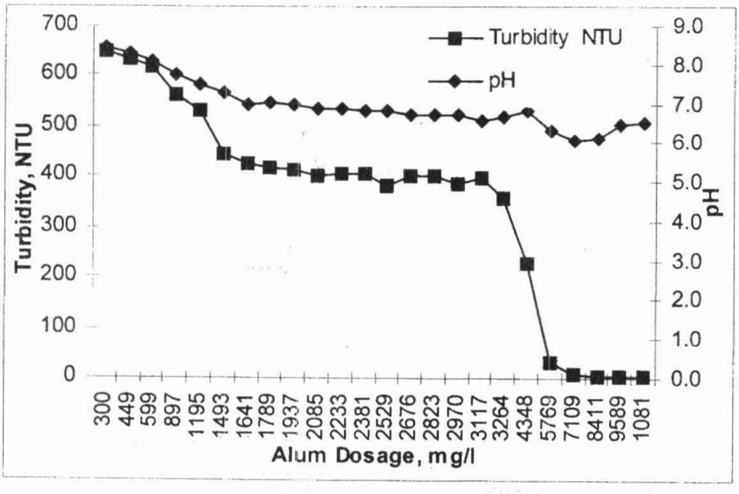

Fig. 3: Turbidty, pH Vs Alum Dosage

Results of COD, TSS and turbidity removals using alum, as shown in above figures, showed considerable reduction in the parameter values with the increase of alum dosage. The pH was also lowered as the alum dosage was increased. This was due to the reaction between alum and water as shown below.

$$Al_2(SO_4)_3 + 6H_2O \longrightarrow 2Al(OH)_3 + 3H_2SO_4$$
$$H^+ + HCO_3 \longrightarrow CO_2 + H_2O$$

In the first reaction, aluminium sulphate reacts with alkalinity and caused an increase in CO_2 and hence reduction in water pH. Thus, lime (NaOH) was added to the sample to increase the pH and from the results it was shown that the pH remained in range of 6 to 8 especially in case of turbidity and TSS.

For the overall optimal condition for all three parameters, the optimal dosage of alum was taken as 6000 mg/l at pH 6 to 6.5. At the optimum dosage removals of 90% COD, 99% turbidity and 60% TSS were achieved.

Use of Ferric Chloride as a Coagulant

When ferric chloride were used as a coagulant, the trend of a 'U' shape solubility curve were obtained. For this coagulant, the pH and dosage were conducted in three different jar tests labelled as A, B and C. Parameters such as COD, TSS and turbidity were monitored. The results indicated that extreme values of pH of either acidic or alkali did not produced satisfactory removals.

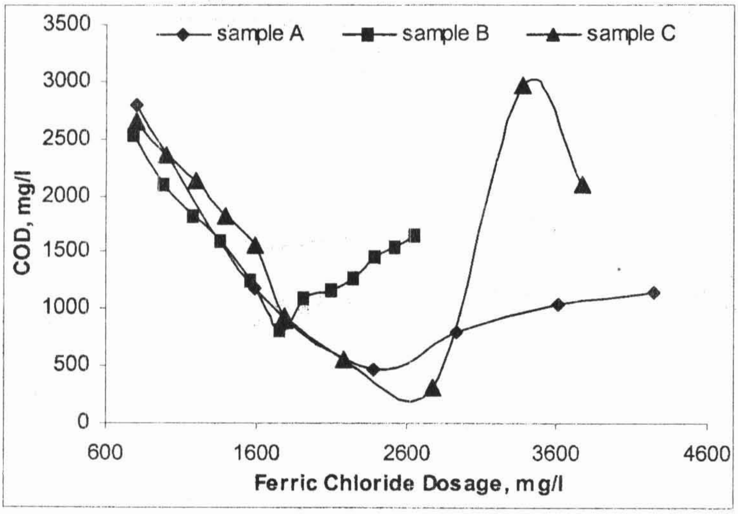

Fig. 4: COD Vs Ferric Chloride Dosage

The most satisfactory result for COD removals was obtained in sample C test at a ferric chloride dosage of 2600 mg/l with a pH of 5.6.

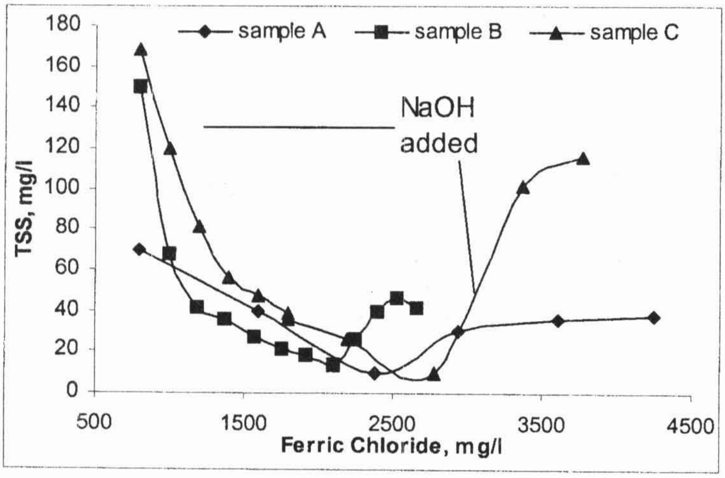

Fig. 5: TSS Vs Ferric Chloride Dosage

For TSS removals, sample C test gave the best results at a ferric chloride dosage of 2600 mg/l with a pH of 5.6 resulting in the final TSS of less than 10 mg/l of TSS.

For turbidity, all three test samples gave turbidity results of less than 10 NTU at their optimum dosages. Sample A test at the optimum ferric chloride dosage of 3000 mg/l and pH 6.3 was taken as the most satisfactory result.

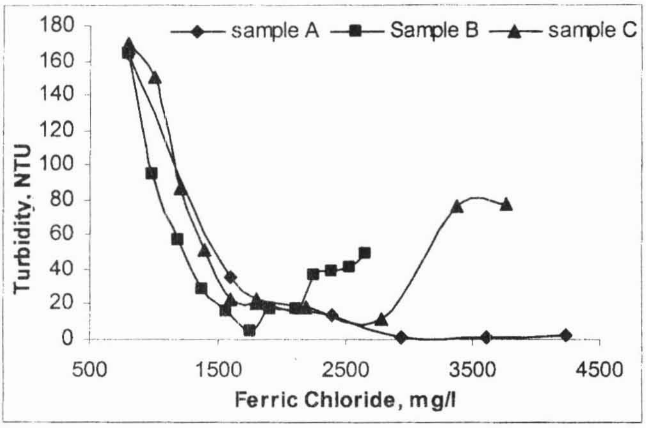

Fig. 6: Turbidity Vs Ferric Chloride Dosage

For the overall optimal condition, the optimum dosage of ferric chloride of 2600 mg/l and pH 5.6 gave the best results for COD and TSS with turbidity well below 10 NTU.
In general, the pH decreased with the addition of ferric chloride due to its reaction with alkalinity of the water.

$$FeCl_3 + 3H_2O \longrightarrow Fe(OH)_3 + 3HCl$$
$$H^+ + HCO_3 \longrightarrow CO_2 + H_2O$$

Recycled iron sludge (RIS)

The results indicated that recycled iron sludge (RIS) was effective in treating the wastestream. Various tests were conducted using palm oil mill effluent to verify the effectiveness of RIS. Initial COD and TSS were found to be 1436 mg/L and 470 mg/L, respectively. It can be seen in Figure 7 optimum RIS dosage was found to be 800 mg/L. Beyond 800 mg/L, the COD and TSS increased which may be due to the formation of oily flocs being produced by the excess of RIS in the solution. At this optimum dosage, COD and TSS removal were found to be 86 % and 50 %, respectively. Hence it can be concluded that RIS is also effective in treating palm oil effluent to meet the effluent limits. Figure 8 shows the removals of COD and TSS using RIS, $FeCl_3$ and Alum as coagulants at their optimum dosages. The TSS removals using RIS, FeC13 and Alum at these dosages were found to be approximately 51 %, 48 % and 46 %, respectively. The COD removals using RIS, FeC13 and Alum at these optimum dosages were found to be approximately 86 %, 80 % and 73 %, respectively

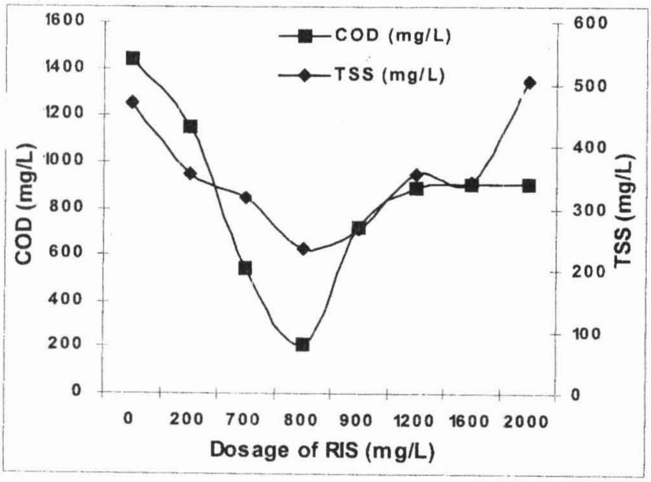

Fig.7: COD and TSS Vs. dosage of RIS

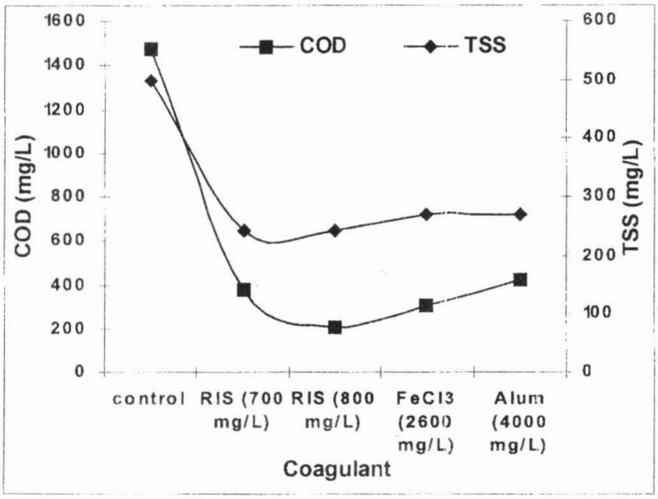

Fig. 8: COD and TSS of some coagulants at their optimum dosage

Conclusion

At an optimum alum dosage of 6000 mg/l and pH 6 to 6.5, removals of 90% COD, 99% turbidity and 60% TSS were obtained. At an optimum ferric chloride dosage of 2600 mg/l and pH 5.6, removals of 95% COD, 98% turbidity and 97% TSS were obtained. Removals of COD and TSS of 86 % and 50 %, respectively were obtained when RIS were used as a coagulant at an optimum dosage of 800 mg/l. In view of the results, it can be concluded that recycled iron sludge (RIS) can act as a suitable coagulant in treating POME. Since a small amount of RIS is required for desired results, the economics also favours its application. The cost involved may only be in the production of RIS. Use of recycled sludge as a source of coagulant may help towards reducing sludge disposal problems and also towards reducing pollution of the environment.

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