CHEMICAL PRECIPITATION OF PALM OIL MILL EFFLUENT

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ABSTRACT

Many palm oil mills failed to comply with the standard discharge limits especially BOD and TSS concentration although they have applied biological treatment system. Hence, it is suggested that coagulation and flocculation process will enhance the BOD and TSS removal so that the final discharge will meet the Department of Environment (DOE) standards besides curtailing the large land area required by the aerobic pond. A study using coagulation–flocculation method as a pre-treatment for palm oil mill effluent (POME) has been carried out. The efficiency of chitosan, polyacrylamide (PAM) and polyaluminum chloride (PACl) as coagulants were explored in this study. Jar test method has been used to identify the best coagulant in removing the organic matter. The reduction of turbidity, BOD, and TSS were the main evaluating parameters. In coagulation–flocculation process, coagulant dosage and pH played an important role in determining the coagulation efficiency. Chemical cost estimation was done to determine the applicability of the type of coagulant and its dosage. At the optimum chitosan dosage (250 mg/L) and pH 5.0, turbidity reduction was found to be 94%, TSS removal was 97% and BOD reduction was 61%. The optimum dosage and pH for PAM were 500 mg/L and 5.0, respectively, at which it gave 44% reduction of turbidity, 94.8% of TSS removal and 63% of BOD reduction. At the optimum PACl dosage (500 mg/L) and pH 6.0, turbidity reduction was found to be 76.3%, TSS removal was 96% and BOD reduction was 59%. For PAM and PACl to obtain a comparable percentage of BOD removal as performed by chitosan, the optimum dosages were 500 mg/L, respectively, employing the same mixing speed and sedimentation time, and a pH value of 5.0 and 6.0, respectively. Amongst the three types of sole coagulant, the total chemical cost of PACl needed per tonne of crude palm oil produced was the cheapest (RM0.85), followed by PAM (RM23.88) and chitosan (RM39.13).

ABSTRAK

Kebanyakan kilang pemprosesan minyak kelapa sawit gagal menepati piawaian pelepasan efluen terutamanya kepekatan BOD dan pepejal terampai (TSS) walaupun telah menggunakan sistem rawatan biologi. Maka kaedah pengentalan dan pengelompokan dicadangkan sebagai pilihan yang lebih baik dalam meningkatkan pengurangan TSS dan BOD supaya efluen akhir menepati piawaian DOE di samping mengurangkan keperluan tanah yang besar untuk kolam aerobik. Kajian menggunakan kaedah pengentalan dan pengelompokan untuk pra-rawatan air sisa kilang kelapa sawit (POME) telah dijalankan. Kecekapan chitosan, poliakrilamida (PAM), dan poli-aluminium klorida (PACl) sebagai bahan pengental dikaji. Ujian balang digunakan untuk mengenalpasti bahan pengental terbaik dalam menyingkirkan bahan organik. Pengukuran pengurangan kekeruhan, TSS dan BOD adalah parameter yang digunakan untuk justifikasi kecekapan rawatan pra-kimia POME. Dalam proses tersebut, dos bahan pengental dan pH memainkan peranan penting dalam menentukan kecekapan proses pengentalan. Analisis kos bahan kimia dilaksanakan untuk menentukan aplikasi jenis bahan pengental dan dosnya. Pada dos optima chitosan (250 mg/L) dan pH 5.0, pengurangan sebanyak 94% kekeruhan, 97% TSS dan 61% BOD berjaya dicapai. Dos dan pH optima bagi PAM ialah 500 mg/L and 5.0, dimana pengurangan sebanyak 44% kekeruhan, 94.8% TSS, dan 63% BOD diperolehi. Pada dos dan pH optima PACl iaitu 500 mg/L dan pH 6.0, penyingkiran 76.3% kekeruhan, 96% TSS dan 59% BOD dapat dicapai. Bagi PAM dan PACl untuk mencapai peratusan pengurangan BOD yang setara dengan chitosan, dos optima yang diperlukan ialah 500 mg/L, melalui halaju pengacauan dan tempoh sedimentasi yang sama, dan nilai pH pada 5.0 dan 6.0, masing-masing. Kos PACl bagi setiap tan penghasilan minyak sawit mentah adalah yang termurah (RM0.85), diikuti PAM (RM23.88) dan chitosan (RM39.13).

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CHAPTER I

INTRODUCTION

1.1 Introduction

Malaysia presently accounts for 51% of world palm oil production and 62% of world exports, and hence also for 8% and 22% of the worlds total production and exports of oils and fats. As the leading producer and exporter of palm oil and palm oil products, Malaysia has a significant role to play in fulfilling the growing global need for oils and fats in general.

The oil palm growth in Malaysia has been bright. The crop has developed to the multi billion ringgit industry as what is witnessed today. In Africa the crop exists wild in the groves facing various constraints in efforts towards domestication. It is in Malaysia that the crop's full potential was utilized. This revolution from wild to domesticated, growing under well managed plantations is not without cost. A great deal of effort went into appreciating this new crop and means of fitting it to its new home.

It was during this development that more was discovered about the crop and its interaction with the environment. Success in the plantation development carried the crop to a new challenge, which is in the processing technology. Malaysia had to take the lead in this new endeavor and developed technologies which are economically sound. Development of the palm industry in Malaysia has been exceptional. From a mere 400 hectares planted in 1920 the area increased to 54 000 hectares in 1960. Many more areas were opened up for oil palm cultivation, either from virgin jungles, or from conversion of plantations that originally supported rubber or other crops since then (MPOB Website).

This increase in area is a direct result of the government's policy on crop diversification. The area under oil palm stood at a staggering 2.6 million hectares by 1996. A corresponding growth in the milling and refining sectors was the result of this fast growth in oil palm planting. Encouraged further by the government incentive to make use of the country's rich agro-based resources, oleochemical processing from palm oil and palm kernel oil began to assume prominence in 1980's. Today, 3.88 million hectares of land in Malaysia is under oil palm cultivation producing 14 million tonnes of palm oil in 2004 (MPOB Website).

Throughout its entire development in Malaysia, both upstream and downstream, the oil palm and its product have always been linked with the environment. Such a rapid increase in both downstream and upstream activities would result in uncontrollable environmental pollution.

To produce palm oil, a considerable amount of water is needed, which in turn generate a large volume of wastewater. Palm oil mills and palm oil refineries are two main sources of palm oil wastewater; however, the first is the larger source of pollution and effluent known as palm oil mill effluent (POME). The palm oil processing became synonymous to POME pollution. An estimated 30 million tonnes of POME are produced annually from more than 300 palm oil mills in Malaysia. The oxygen depleting potential of POME is 100 times that of domestic sewage.

Owing to the high pollution load and environmental significance of POME, an emphasis ought to be placed on its treatment system.

The year 1978 witnessed the enactment of the Environmental Quality Regulations detailing POME discharge standards. Biochemical Oxygen Demand (BOD) was the key parameter in the standards. From the initial BOD of 25 000 ppm of the untreated POME, the load was reduced to 5 000 ppm in the first generation of discharge standard, down to the present BOD of 100 ppm (Malaysia, 1977).

1.2 Background of Research

Wastewater, also known as sewage, originates from household wastes, human and animal wastes, industrial wastewaters, storm runoff, and groundwater infiltration (Lin, 2001). An understanding of physical, chemical and biological characteristics of wastewater is very important in design, operation and management of collection, treatment, and disposal of wastewater. The nature of wastewater includes physical, chemical and biological characteristics which depend on the water usage in the particular industry.

Depending on the nature of the industry and the projected uses of the waters of the receiving streams, various waste constituents such as soluble organics and suspended solids, may have to be removed before discharge (Eckenfelder, 2000).

The natural waters in streams, rivers, lakes, and reservoirs have a natural waste assimilative capacity to remove solids, organic matter, even toxic chemicals in the wastewater. However, it is a long process. Wastewater treatment facilities are designed to speed up the natural purification process that occurs in natural waters and to remove contaminants in wastewater that might otherwise interfere with the natural process in the receiving waters (Lin, 2001). Methods of treatment consist of physical, chemical and biological unit process.

The principal chemical unit processes used for wastewater treatment include chemical coagulation, chemical precipitation, chemical disinfection, chemical oxidation, advance oxidation processes, ion exchange, and chemical neutralization, scale control, and stabilization (Metcalf and Eddy, 2004). Nevertheless, coagulation (i.e. physicochemical destabilization of the colloidal system) and flocculation (i.e. the aggregation of the particles) are most important in many water and sewage treatment processes (Pawlowski, 1982).

There are quite a number of effluent treatment systems which are currently used by the Malaysian palm oil industry. Among them are anaerobic/facultative ponds, tank digestion and mechanical aeration, tank digestion and facultative ponds, decanter and facultative ponds, and physicochemical and biological treatment. Treatment of POME has also been tried using membrane technology, an up-flow anaerobic filtration, an up-flow anaerobic sludge blanket and an up-flow anaerobic sludge fixed film bioreactor. At present 85% of POME treatment is based on an anaerobic and facultative ponding system, which is followed by another system consisting of an open tank digester coupled with extended aeration in a pond (Vijayaraghavan *et al*., 2007).

Chemical treatment of palm oil wastewater was investigated using physicochemical treatment i.e. coagulation and flocculation. It is currently an attractive option in POME treatment that numerous studies had been done on its application in POME treatment system. The results showed that by applying alum, 93% suspended solid removal can be achieved (Ahmad *et al*., 2003a). Application of chitosan as a coagulant showed the best performance as compared to activated carbon and bentonite with more than 99% residual oil and suspended solid removal (Ahmad *et al*., 2005b). Chitosan, besides being environmentally friendly, performed better when compared to alum and polyaluminum chloride (PACl) (Ahmad *et al*., 2006). Ariffin *et al*. (2005) concluded that cationic polyacrylamide (PAM) gave 99% turbidity and total suspended solid (TSS) removal, and 40% Chemical Oxygen Demand (COD) removal. Bhatia *et al*. (2007a) studied the advantage of *Moringa Oleifera* seeds usage. 99% TSS removal can be achieved when utilized with flocculant (NALCO7751). The use of polymeric agent in the treatment of POME was also considered (Ng *et al*., 1987; Ismail and Lau, 1987).

In the present scenario of POME treatment, anaerobic digestion is followed by aerobic oxidation in facultative and algae ponds. Hence, in this study, the coagulation and flocculation process is proposed as a pre-treatment before the anaerobic digestion process with the intention of increasing the BOD and TSS removal so that the final discharge will meet the Department of Environment (DOE) standards besides curtailing the large land area required by the aerobic pond. The efficiency of the coagulation and flocculation process was evaluated by treating the mixed raw effluent obtained from the effluent treatment plant of Kilang Sawit Penggeli, Felda Palm Industries Sdn. Bhd.

POME is a voluminous, high BOD liquid waste. It has total solids content of 5–7% which a little over half is dissolved solids, and the other half being a mixture of various forms of organic and inorganic suspended solids. This property, coupled with its high BOD loading and low pH, makes it not only highly polluting but also extremely difficult to treat by conventional methods. The crude palm oil production of 985,063 tonnes used 1,477,595m^3 of water, and 738,797m^3 was discharged as POME (Bhatia *et al*., 2007a). A new and improved POME treatment technology would be required in order to meet the requirements of DOE discharge limits (400 mg/L TSS and 100 mg/L BOD) and to curb watercourses pollution. There are many processing plants failed to comply with the standard discharge limits even though they have applied biological treatment system.

1.3 Problem Statement

A variety of coagulants has been studied to assess their ability to destabilize the POME suspension and to flocculate the particulate matter. The conditions that would allow for optimal use of the respective chemicals were noted especially for suspended solid removal. However, the magnitudes of the increase in the BOD removal rate by the application of the coagulants are still vague as there is currently little published information on the use of coagulants in POME treatment for BOD removal, with much of the information that is available being proprietary in nature. Most studies performed did not carry out chemical cost analysis which is equally important so as to determine the most cost effective process.

This study was designed to measure the effectiveness of chitosan, PACl and PAM as coagulants for POME treatment by assessing the removal efficiency of TSS, turbidity and BOD and to verify the most suitable and cost effective coagulant for coagulation and flocculation of POME.

1.4 Objectives of Research

The project was aim to achieve the following objectives:

1. To study the potential and effectiveness of chitosan, PACl and PAM as coagulants for POME treatment by assessing the removal efficiency of TSS, turbidity and BOD.
2. To determine the optimum dosage of coagulant needed to achieve maximum removal of TSS, turbidity and BOD.

3. To observe the influence of pH on the coagulation process and thus identify the optimum pH which will give the highest removal.
4. To verify the most suitable and cost effective coagulant for coagulation and flocculation of POME.

1.5 Scope of Research

The research primarily focused on the chemical pre-treatment of POME, collected from Felda Palm Industries Sdn. Bhd (Kilang Sawit Penggeli), by using chitosan, PACl and PAM as coagulants. TSS, turbidity and BOD removal efficiency was determined in order to observe the performance of each coagulant.

Coagulation and flocculation process was carried out via jar test apparatus, in which the optimum dosage of each coagulant to coagulate the mixed raw effluent at the initial pH was identified. Alteration of the effluent's initial pH was done so as to verify the most optimum condition which will give the highest removal efficiencies. This was followed by the chemical cost analysis with the purpose of selecting the most suitable and cost effective coagulant.

1.6 Significance of Research

Palm mills in Malaysia is facing the challenge of balancing environmental protection, their economic viability, and sustainable development after the DOE enforced the regulation for the discharge of effluent from the crude palm oil industry, under the Environmental Quality (Prescribed Premises) (Crude Palm Oil)

Regulations 1977. Quite a number of mills' discharge did not meet the effluent standards as stipulated by the DOE Malaysia. This indicates that up-grading of the existing wastewater treatment plants has to be made in order to comply with the effluent standards established by the authorities. The immediate implication of this research is readily observable. By applying chemical pre-treatment in the POME treatment system, it will significantly improve the treatment system and thus improve the quality of the effluent discharge from the mill and reduce potential environmental liabilities. The findings from this study will also provide way to the most feasible and economical unit processes which can be further studied on a pilot plant scale.

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