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TREATMENT OF PALM OIL MILL EFFLUENT (POME) BY USING ELECTROCOAGULATION AS AN ALTERNATIVE METHOD

(Rawatan Efluen Kilang Sawit Menggunakan Elektrokoagulasi Sebagai Kaedah Alternatif)

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Abstract

The treatment of palm oil mill effluent (POME) is a crucial stage to prevent from environmental pollution. An alternative method should be implemented to replace the conventional wastewater treatment method. Concentration required by the Department of Environment (DOE) is 200 mg/L for chemical oxygen demand (COD) and 100 mg/L for total suspended solid (TSS). Electrocoagulation was used to reduce the amount of COD and TSS in POME. The performance of COD and TSS removal using electrocoagulation was scrutinized. Electrocoagulation reactor was used and the optimum operating parameters were determined. The voltage parameter was manipulated in order to identify the effect on the removal efficiency of COD and TSS. The highest removal efficiency obtained were 95.71% for COD and 99.25 % for TSS in which COD reduced from 4900 mg/L to 210 mg/L meanwhile TSS from 4000 mg/L to 30 mg/L. The final COD almost meets the requirement of DOE of 200 mg/L while TSS fulfil the requirement of 100 mg/L for standard B. The highest efficiency obtained at optimum pH 7.44, electrocoagulation time 25 min and voltage of 100V by using aluminium electrodes. This method was found to be efficient and capable to reduce time of treatment compared to standard conventional method.

Keywords: palm oil mill effluent, wastewater treatment, electrocoagulation, chemical oxygen demand, total suspended solid

Abstrak

Rawatan efluen kilang minyak sawit (POME) adalah satu peringkat penting untuk mencegah dari berlakunya pencemaran alam sekitar. Satu kaedah alternatif perlu dilaksanakan untuk menggantikan kaedah rawatan air sisa konvensional. Kepekatan yang ditetapkan oleh Jabatan Alam Sekitar (JAS) adalah 200 mg/L untuk keperluan oksigen kimia (COD) dan 100 mg/L untuk jumlah pepejal terampai (TSS). Elektrokoagulasi telah digunakan untuk mengurangkan jumlah COD dan TSS dalam POME. Prestasi COD dan TSS penyingkiran menggunakan electrokoagulasi telah diteliti. Reaktor elektrokoagulasi digunakan dan parameter operasi yang optimum telah ditentukan. Parameter voltan telah dimanipulasi untuk mengenal pasti kesan pada kecekapan penyingkiran COD dan TSS. Kecekapan tertinggi penyingkiran yang diperoleh 95.71% untuk COD dan 99.25% untuk TSS di mana COD dikurangkan daripada 4900 mg/L kepada 210 mg/L manakala TSS dari 4000 mg/L kepada 30 mg/L. COD akhir hampir memenuhi keperluan JAS iaitu 200 mg/L manakala TSS telah memenuhi kehendak 100 mg/L untuk standard B. Kecekapan tertinggi diperoleh pada pH optimum 7.44, masa elektrokoagulasi 25 minit dan voltan 100V dengan menggunakan elektrod aluminium. Kaedah ini didapati berkesan dan mampu untuk mengurangkan masa rawatan berbanding dengan kaedah piawai konvensional.

Kata kunci: efluen kilang minyak sawit, rawatan air sisa, elektrokoagulasi, keperluan oksigen kimia, jumlah pepejal terampai

Introduction

Agriculture based industry is a well expand industry in Malaysia and contribute to 11% of Malaysia's gross domestic product (GDP). The agricultural research and development had been developed in Malaysia in the 5th

Malaysia Plan (1986-1990) and keep growing [1]. Palm oil industries have great achievement in term of economics. Palm oil trees are originally from West Africa is brought by the British in Malaya in the early 1870's as an ornamental plant. The first commercial planting are located in Tennamaran Estate in Selangor. It is the steps of beginning of palm oil industry in Malaysia and now about 4.49 million hectares of land in Malaysia are under oil palm cultivation [2]. Furthermore, the palm oil industry has become an important agriculture based industry over the last three decades. This is because, 90% of global palm oil is produced by Malaysia and Indonesia to fulfil the current and future demand. Other than that, Malaysia contributes 39% of world's palm oil production and 44% of world's export. If taken into account of other oils and fats produced in the country, for about 12% and 27% of the world's total production and exports of oils and fats are accounts by Malaysia. Malaysia has an important role to play as being one of the biggest producers and exporters of palm oil and palm oil products. In fact, it also plays a role in fulfilling the growing global need for oils and fats sustainably [3]. With this advanced development of palm oil industry, the number of processing factory will be kept growing.

As these industrial sectors are getting expand, more pollution occurrence happened due to release of wastes. Every industry consumed a lot of water during the process and release large amounts of wastewater [4]. It will bring problem towards the quality of environment if the treatment process is not well organize. Industrial wastewater contains so many substances and not suitable to be directly discharged to the river because it can cause harm to the aquatic life. The most common method in treating Palm oil mill effluent (POME) is using a conventional ponding method. It is about 85 % of palm oil mills in Malaysia had taken this method as their way to treat the POME. The reason of using ponding system is due to its cost that is low cost in term of labour compared to other treatment method [5]. There is some problem with ponding system in which it needs a large surface area of land [6]. In fact, the treated POME using ponding system also sometimes do not pass the standard industrial discharge [7]. Current wastewater treatment technologies such as using physical, chemical and biological treatment require a lot of money to be spent [8].

Electrocoagulation is one of the alternative methods that can be used in wastewater treatment. It is a simple and efficient technology [9]. Electrocoagulation is a novel method in wastewater treatment and this emerging technology combines the functions and advantage of conventional methods such as coagulation, flotation, and electrochemistry in water and wastewater treatment [10]. During the process, hydrogen gas is also released and this helps to float up the flocculated particles to the surface of water. The hydrogen produce by the electrolytic is almost no pollution [11]. Electrocoagulation is considered as an economical and environmental friendly because it is portable and only need an optimum space to locate the system. This process only used a simple and compact reactor without generating secondary pollutants [12]. It is said that the flocks' produces this process is larger [13]. Other than that, less bound water contains and no extensive chemical required [14].

The main purpose of this research study is to treat palm oil mill effluent by using electrocoagulation in order to determine the effectiveness of electrocoagulation using aluminium (Al) electrodes in the removal of chemical oxygen demand (COD) and Total Suspended Solid (TSS). The optimum electrocoagulation time and voltage applied are determined to obtain the best removal efficiency of COD and TSS.

Materials and Methods

Palm Oil Mill Effluent

The sample of POME was obtained from Felda Palm Industries Sdn. Bhd, Felda Lepar Hilir 3, Gambang, Pahang. The sample was obtained from anaerobic pond. POME sample taken was stored in the chiller at 6 °C to prevent the changes on its characteristics.The sample was kept not more than two weeks to avoid excessive deterioration and then should be discarded [15]. Pysico-chemical properties of sample taken was measured and summarized in Table 1.

Table 1. Physico-Chemical properties of POME wastewater

Parameter	**Value**
Chemical Oxygen Demand	4900 mg/L
Biological Oxygen Demand	810 mg/L
Total Suspended Solid	4000 mg/L
pH	7.44

Experimental Apparatus and Procedure

In this experiment, OMARtech electrocoagulation reactor was used to treat the POME. The optimum condition of pH for the electrocoagulation to operate effectively has been determined which in range from 6.5-8.0. Initial pH can bring significant influence towards the performance of the electrocoagulation process [16]. The voltage value of this reactor was manipulated from 0V to 100V. The anode and cathode used to be aluminium electrode. In order to get higher efficiency, the electrodes were clean with abrasive paper. Before the sample was treated using electrocoagulation, the sample was filtered to remove the solid particle in POME. All the initial significant parameters are recorded as in Table 1 above. Three litres of sample was used in every experiment with different voltage value applied. The experiment started with 0V and then the treatment was done with the maximum electrocoagulation time of 25 minutes. In every 5 minutes, the sample was taken for the analysis. Then, same steps were repeated with new sample using different voltage of 25V, 50V, 75V and lastly 100V. The samples taken were filtered and being settled down for 24 hours in a chiller before it can be analyzed so that all the sediment goes down and increase the removal efficiency of COD and TSS. After 24 hours, the samples were ready for analysis.

Chemical Oxygen Demand Analysis

Hach DR 2400 spectrophotometer was used to analyze the concentration of COD of the treated sample. The range for the spectrophotometer is 1500 mg/L hence every sample needs to be diluted before they can be analyzed. The high range COD vial was used in this analysis because the concentration of COD of POME is very high and need to be diluted. Hach DBR 200 COD digestion reactor was preheated to 150 °C before the vial can be placed in it. 2 mL of diluted sample was pipetted into the COD vial and it is called as prepared sample. Meanwhile, another vial was added with 2 mL of deionized water and act as blank. Both of the vials are cap tightly and rinse with deionized water and wipe with clean paper towel. Both vials are invert gently to mix, placed in the reactor and heated for 2 hours. Then, the vials were cooled to room temperature before the COD concentration can be read using Hach DR 2400 spectrophotometer.

Total Suspended Solid Analysis

A set of Buchner flask was used to determine the amount of TSS in the treated samples. Filter disks were dried in oven at 103 °C for an hour before it can be used to filter the sample. Then, 20 ml of the sample was used to be sucked using the pump through the Buchner flask. Steps applied for all samples. After that, the filters were dried again in the oven at the same temperature of 103 °C for an hour. The initial and after filtration weight of filter paper were recorded in order to determine the concentration of TSS. The TSS in the wastewater samples were calculated using the following formula equation 1:

$$\frac{mg}{L}\ TSS = \frac{(W_B - W_A)}{Sample\ Volume,mL}\ x\ 100 \quad (1)$$

where W_A is Initial Weight of filter paper and W_B is Final Weight of filter paper

pH analysis

A Mettler Toledo pH meter was used to determine the pH of POME wastewater. In order to get an accurate reading, calibration was done before the measuring probe can be used. Calibration was done by rinse the probe with distilled water and dab with Kimwipe tissue. Then the probe was submersed in buffer solution of pH7, and rinse

again with distilled water. This step was repeated by using buffer solutions of pH4 and pH 10 consecutively before probe can be applied in the POME sample. The reading is taken when the pH icon on pH meter had stop flashing.

Results and Discussion

Determination of COD and TSS Removal Efficiencies

The calculation of COD and TSS removal efficiencies were performed using this formula equation 2 [17].

$$RE(\%) = \frac{Co - C_i}{Co} x\ 100 \quad (2)$$

Based on the equation, Co and Ci are the concentrations of COD before and after electrocoagulation in mg/L respectively. Same equation applied for the calculation of TSS removal efficiency.

Determination of Optimum Electrocoagulation Time and Voltage

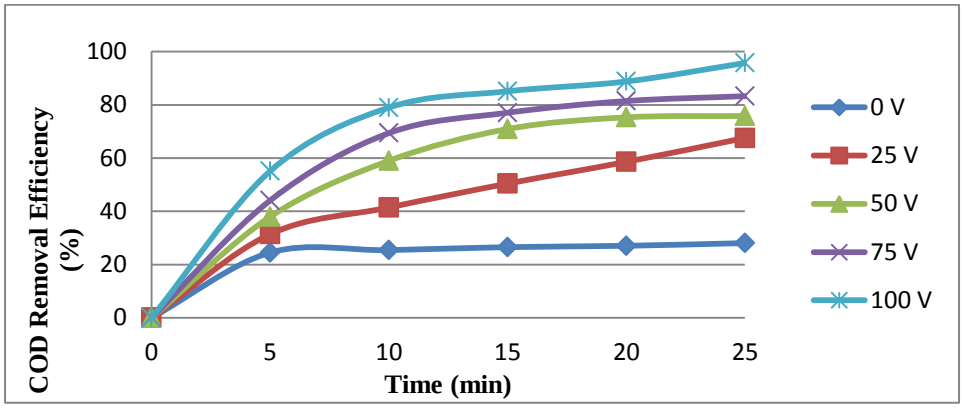

Figure 1. Percentage removals of COD of POME from anaerobic pond at voltage of 0V, 25V, 50V, 75V and 100V

The applied voltage is expected to give significant effect on the COD removal. It is expected that the COD removal will getting increase with the increasing voltage and electrocoagulation time. Based on Figure 1, it shows the COD removal efficiency (%) of every sample run using different voltage for 25 minutes. The removal efficiency of COD was increasing with increasing of voltages applied and time of treatment time. The highest removal of COD was obtained at 100 V and 25 minutes of electrocoagulation time in which the initial COD concentration was 4900 mg/L and was reduced to 210 mg/L. It gave 95.71 % of removal efficiency. Results show that the highest removal efficiency for every voltage value occurs at 25 minutes of treatment. The highest efficiencies for voltage of 0 V, 25 V, 50V, and 75 V were 28.06 %, 67.55 %, 75.82 %, and 83.27 % respectively. The COD concentration of 210 mg/L almost meets the requirement of DOE, which is 200 mg/L for Standard B. This showed a positive result and this method has the potential to be commercialized in industry in Malaysia.

Figure 2 shows the TSS removal efficiencies for the sample at different voltage value and electrocoagulation time. The initial concentration of TSS is 4000 mg/L and the highest reduction was reduced to 30 mg/L at 100V and 25 minutes electrocoagulation time with the removal efficiency of 99.25 %. It also shows that the highest removal efficiency for every voltage value occur at 25 minutes of treatment. The highest efficiencies for voltage of 0 V, 25 V, 50V, and 75 V were 17.25 %, 81.75 %, 98.50 %, 97.75%. It can be concluded that the optimum condition for best electrocoagulation performance on POME is at 100V with 25 minutes of operating time. As voltage increase, the bubble density and size increases. Besides, it also causes a greater upward flux and rate of pollutant removal and sludge floatation increase [18]. The final concentration of TSS of 30 mg/L already meets the Standard B requirement by DOE, which is 100 mg/L for TSS. This shows there is potential for electrocoagulation to be applied in industry.

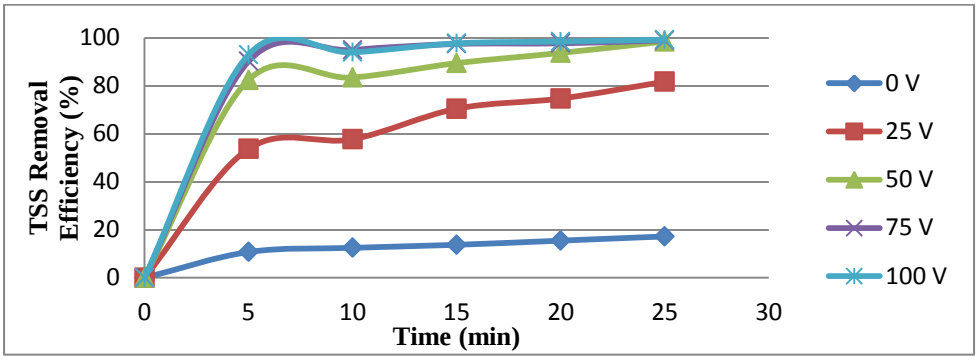

Figure 2. Percentage removals of TSS of POME from anaerobic pond at voltage of 0V, 25V, 50V, 75V and 100V

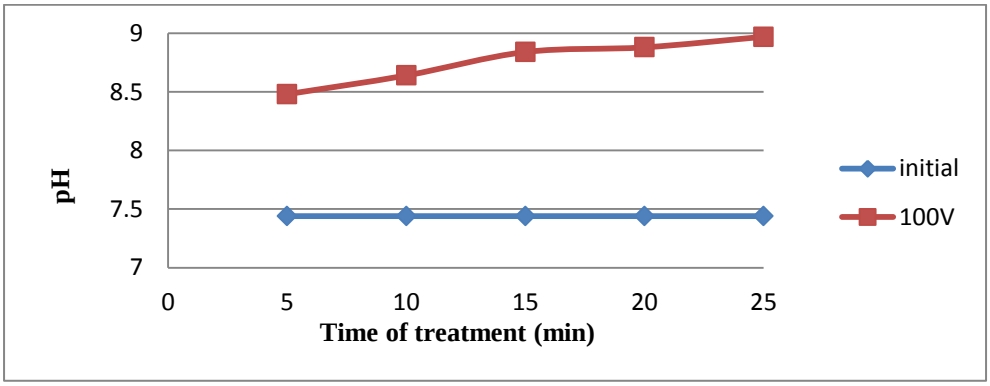

Figure 3. Effect of electrocoagulation time on pH revolution for Al-Al at pH 7.44, voltage of 100V and 25 minutes of treatment time

Figure 3 shows the effect of electrocoagulation on the pH evolution. The data are taken at the significant 100V treatment. The final pH recorded was higher than the initial value. As for determination of optimum voltage, the POME from anaerobic pond with pH 7.44 was used for all the tested voltage. At the end of the electrocoagulation process 25 minutes, the measured pH at a voltage of 0V, 25V, 50V, 75V and 100V have increased to pH 8.74, 8.62, 8.42, 8.64, and 8.97 respectively. During an an electrochemical process it is generally known that the pH value will increase. This is due to the cathodic activity occurs that release the hydroxyl ions or metal hydroxide [19, 20].

Conclusion

This study has shown that the electrocoagulation is an efficient method in treating palm oil mill effluent. Chemical oxygen demand and total suspended solid were reduced by more than 90 % removal and this is a positive result for using electrocoagulation in palm oil industry. The final concentration of COD and TSS were 210 mg/L and 30 mg/L with the reduction of 95.71% and 99.25% respectively. Meanwhile the requirement of DOE for standard B effluent was 200 mg/L and 100 mg/L for COD and TSS. So, the result obtained almost satisfies the requirement. In order to achieve higher removal efficiency for COD and TSS, further study of electrocoagulation time, voltage applied and other parameters is encouraged. This study shows that electrocoagulation can be an alternative method for palm oil industries in Malaysia in treating the wastewater.

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