Jurnal
Teknologi

Full Paper

EVALUATION OF SLUDGE FROM COAGULATION OF PALM OIL MILL EFFLUENT WITH CHITOSAN BASED COAGULANT

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Article history
Received
5 June 2015
Received in revised form
6 September 2015
Accepted
7 December 2015

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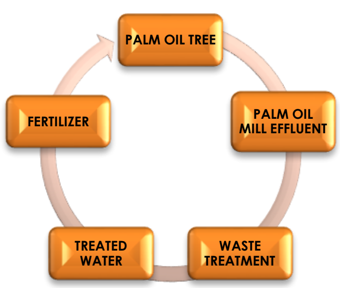
Graphical abstract



Abstract

Palm Oil Mill Effluent (POME) have been declared as one of the major source of environmental pollution due to indiscriminate discharge into watercourses. POME contained appreciable amount of nutrients that is beneficial to plants. However, direct usage of POME would results in toxification of plants and crops. Extraction of these nutrients would be beneficial for agricultural purposes. In this study, the sludge obtained from coagulation and flocculation of POME using chitosan based coagulant was evaluated. In addition, the fertility of the sludge was also evaluated by a set of pot trial tests using *Scindapsus Aureus*. Comparison was made using commercially available fertilizer. It was found out that macronutrients such as Nitrogen (N) and Phosphorus (P) initially contained within POME were removed, however the removal of Potassium (K) was found to be less effective. Interestingly, pot trial test results indicated that *Scindapsus Aureus* grows better using chitosan based sludge as compared to commercially available fertilizer.

Keywords: Palm oil mill effluent, Chitosan, Ferric Chloride

1.0 INTRODUCTION

The palm oil industry has been identified as the main national key economic area (NKEA) in Malaysia which contributed to the country's gross national income (GNI). To date, The Malaysian palm oil industry has grown rapidly over the years and Malaysia has become one of the world's largest producer and exporter of palm oil [1][2]. However, coupled with the production of palm oil, a significant amount of palm oil mill effluent (POME) is also produced. POME have been declared as one of the major source of environmental pollution due to indiscriminate discharge of untreated or partially treated POME into public watercourses [3]. Raw POME is a thick brownish in colour liquid which is highly concentrated colloidal slurry with pH between 4.0-5.0, brownish colloidal suspension that containing high concentration of organic matter. It contains mainly water (95% - 96%), suspended solids (2% - 4%) and oil (0.6% - 0.7%). Freshly discharged POME has temperature between (80°C - 90°C) and possesses a very high Biochemical Oxygen Demand (BOD), which is 100 times as polluting as domestic sewage [4]. POME also contains appreciable amounts of Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca) and Magnesium (Mg) which are vital nutrient elements for plant growth [5].

In the past, POME has been successfully treated using several conventional treatment methods of wastewater treatment namely aerobic pond system [6], anaerobic pond system [5]. However, the retention times of the anaerobic systems vary from 45-60 days respectively [7]. According to [8], anaerobic process is a most suitable treatment method due to the high organic characteristic of POME. Usually anaerobic stabilization ponds are widely used for treatment of wastewater from palm oil production because it has low capital and operating cost. Although these systems seems to be the most effective biological treatment method, the constraints lies on the availability of sufficient land for building the ponds and the length of the retention time taken to treat the POME.

In recent years, more advanced treatment was proposed such as the use of membrane technology [4], and electrocoagulation process using high currents [9]. Alternatively, coagulation and flocculation process were adopted. Coagulation is the most commonly employed treatment process for the removal of colloidal particles and organic matter in wastewater such as POME [10]. The feasibility of treating POME within a short period of time without involving a vast area of land by using coagulating and flocculating agents may offer a solution to the treatment problems. It has been reported that the chemical coagulation is the fastest way to reduce the organic load of the POME to an acceptable and economical level [11]. Up to 60% removal of BOD and COD was achieved. In addition, 90% of the suspended solid (SS) was completely stripped with proper selection of chemical coagulant and its optimum dosage. Coagulant such as Aluminium Sulphate (Alum), Polyaluminium Chloride (PAC), Ferric Sulphate and organic based biocoagulants [3], [12], [13] has shown promising results. However, as compared to biocoagulant, the use of chemical coagulation and flocculation process produced significant amount of sludge to be disposed of after treatment [14]. In the case of POME treatment, nutrients are usually removed along with these sludges. Thus utilizing these sludge as alternative to fertilizers may be beneficial for agricultural purposes and reduced the amount of landfilling activities. Literature suggested that, even though coagulation and flocculation may be one of the best methods for treating POME however, researchers in the past are more oriented towards the effectiveness of the treatment rather than the applicability of the sludge as alternative fertilizer.

In this study, POME was initially treated using chitosan based bio coagulant agent. A chemical coagulant was also used to speed up the coagulation process. The effectiveness of these processes in removal of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonium Nitrogen (NH_4N), Phosphate (P) and Potassium (K) was determined. In addition, the fertility of the sludge obtained from the treatment process was evaluated.

2.0 EXPERIMENTAL

2.1 Materials

Sample of raw POME was collected from Sime Darby Palm Oil Mill Jabor. Shrimp source chitosan was purchased from a local manufacturer, Hunza Pharmaceutical Sdn. Bhd., Malaysia in the form of yellowish powder. This chitosan was soluble in 1% diluted acetic acid with a 90% degree of deacetylation.

2.2 Preparation of Chitosan Gel

Chitosan gel was initially prepared following methods described by Ahmad *et al*. [3]. About 10 g of chitosan was dissolved in 10 mL of acetic acid (0.1 M) and 980 g distilled water. The solution was then stirred using a magnetic stirrer to make sure all the solution are mixed formed gel. Then, the same method was repeated with different ratios, distilled water and acetic acid, namely 970 g distilled water, 30 g chitosan: 10 mL acetic acid: 960 g distilled water, 35 g chitosan: 10 mL acetic acid: 955 g distilled water.

2.3 Methods

2.3.1 Coagulation and Flocculation

500 mL of raw POME was placed in 1-L beaker. Magnetic stirrer was used to coagulate the samples of POME with chitosan gel with and without the addition of $FeCl_3$. The mixtures were then placed under a magnetic stirrer and stirred to mix the solution until completely mixed. The pH of the POME sample was monitored using a Mettler Toledo pH meter. Then, the stirrer was switched off and the suspensions were kept in still condition to settle for approximately 1 hour. Then, the suspended solid formed was separated via a filter and a vacuum pump having a constant pressure of approximately 20 Hg/mm. In addition, a Whatman filter paper type No 1820-047 was used as a separation medium in order to prevent blockage to the filters. The precipitates were placed in an oven at 105°C for 24 hours to remove access water from the sludge produced.

2.3.2 Pot Trial Test

To evaluate the fertilizing value of precipitate, a species of rapid growing plants native to Malaysia, *Scindapsus Aureus* or "Sirih Gading" was selected for the pot trial tests. Each of the plants were grown in four different conditions: control, commercial fertilizer, with $FeCl_3$ and without $FeCl_3$. All the pots were observed on daily basis and the length of the leaf were measured. After 14 days growth, all their growth rates were compared.

2.5 Water Quality Analysis

Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonium Nitrogen (NH_4N), Phosphate (P) and Potassium (K) were measured using recommended method by APHA Standard Method Examination of Water and Wastewater [15]. All the parameters of the samples were determined both prior to and after the coagulation and flocculation tests. Three replicates of each test were undertaken with the mean value obtained for all the parameters being calculated from the replicates. All tests were carried out at an ambient temperature of 25 °C. The concetration of Potasssium (K), in POME was determined by Inductively Coupled Plasma Mass Spectrometry (ICPMS 3300 DV, Perkin Elmer).

3.0 RESULTS AND DISCUSSION

Table 1 shows the initial parameter of raw POME considered in this study. Referring to Table 1, the COD value was found to be greater than that of BOD value. The COD/BOD values was found to be greater than 2.5. Macronutrients (i.e. N, P and K) are essential to plant growth, however, it was noted that the concentrations of NH_4-N and P were noticeably similar and was found to be significantly lower than K concentration.

Table 1 Concentration of Raw POME

Parameter	Concentration (mg/l)
BOD	34500
COD	89000
NH_4-N	180
P	190
K	1900

3.1 Effect of Chitosan Dosage on NH_4-N,P,K Removal

Figure 1 shows the effect of different dosage of chitosan gel in removal of NH_4-N, P and K. The results for percentage removal of nutrient by the variation of chitosan dosage with $FeCl_3$, which are summarized in Figure 1 (a), showed that the percentage removal of phosphate (P) for all the different of chitosan dosage was more than 85%. Compared to Figure 1 (b), the highest percentage removal of phosphate was only 63.16% with the 30 g/l chitosan dosage. However, the Ammonium Nitrogen (NH_4-N) and Potassium (K) content in Figure 1(a) are not effected when the chitosan dosage were increased to 30 and 35 g/l. Similar observation was reported by [13][14] that significant increase in chitosan concentration will inevitably affect the efficiency of treatment.

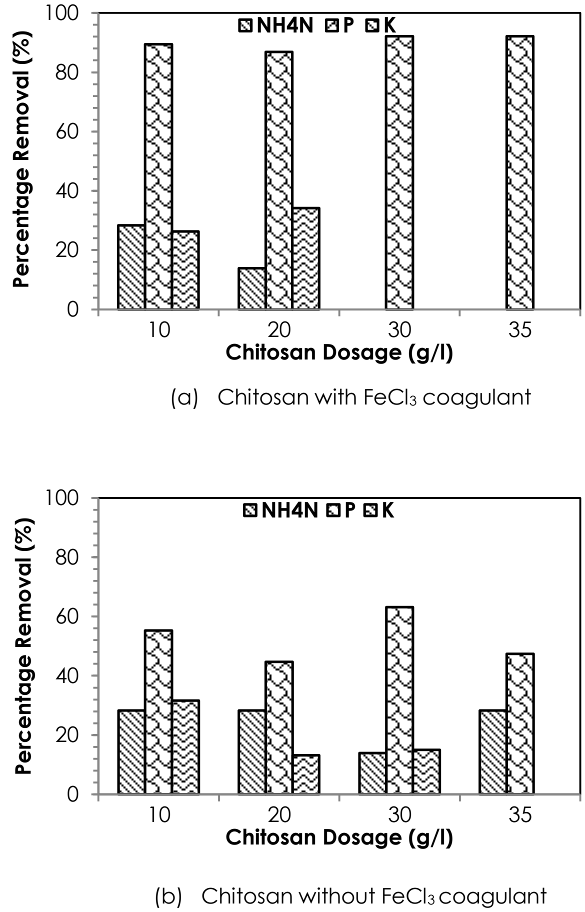


Figure 1 Percentage Removal of nutrient with the variation of chitosan dosage (a) with FeCl3 and (b) without $FeCl_3$

3.2 Pot Trial Test

To study the effectiveness of sludge produced as fertilizer, the length of leaf of each pot were measured on daily basis up to a period of 14 days. Comparison was made between plants cultured in testing conditions as shown in Figure 2. The fertilizer of 10 g/l chitosan dosage from Figure 1 (a) and (b) was chosen as fertilizer for with and without $FeCl_3$ pot respectively since its shown the best removal of nutrient compared to other chitosan dosage. The length of leaf in the with $FeCl_3$ and without $FeCl_3$ pots grew much longer than those in the control pots due to poor nutrient status, but there was no significant difference of the length of leaf growth between with and without $FeCl_3$ as shown in Figure 2. Figure 2 also indicated that, surprisingly, based on the growth of the plants, the sludge obtained from this study performed more superior to that of commercially available N, P,K fertilizers.

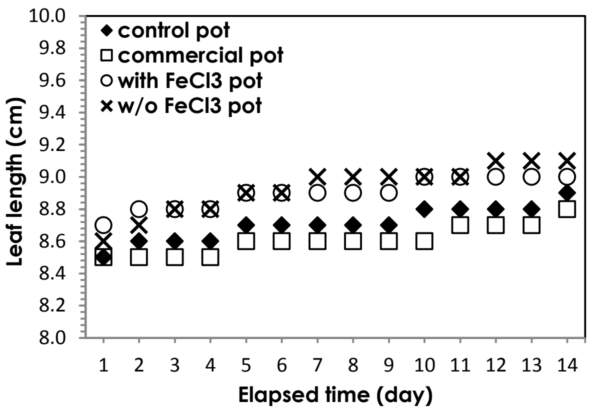


Figure 2 Length of leaf growth by time (day)

4.0 CONCLUSION

Experimental tests were performed to evaluate the chitosan ability as natural coagulant for treatment of palm oil mill effluent. Test results indicated that chitosan as biocoagulant is effective in removal of nitrogen and phosphorus. Potassium removal on the other hand, was found to be less effective. Even though concentration of phosphorus contained within the sludge was found to be low, the fertility of the sludge on *Scindapsus Aureus* was found to be superior to that of planted using commercially available fertilizer.

Acknowledgement

The authors greatly acknowledge the financial support provided by the Malaysian Ministry of Higher Education under RAGS research grant RDU131417.

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