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TURBIDITY AND SUSPENDED SOLID REDUCTION FROM PALM OIL MILL EFFLUENT USING COCONUT SHELL CHARCOAL

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ABSTRACT

An attempt was made to the changes of turbidity and suspended solid of palm oil mill effluent (POME) using activated biocarbon (bio-char) made up from coconut shell. The complete study was done in batch mode to investigate the effect of various operating parameters. The effect of treatment time, adsorbent dosage, agitation speed and pH was significantly effect on the turbidity and suspended solid in POME. Using 0.5 g of coconut shell charcoal (CSC)/100 ml at pH 4.2 with 90 rpm agitation speed in 10 minute the turbidity and suspended solid was reduced up to 84.3 % and 86.7% respectively. As a huge reduction of turbidity and suspended solid in POME, it could be a lucrative technique for treatment of domestic wastewater generated in palm oil sectors.

***Keywords**: Palm oil mill effluent; coconut shell carbon; adsorption; turbidity; suspended solid*

INTRODUCTION

One of the most important and profitable crops in Malaysia is oil palm. Nowadays, Malaysia has made up about 425 fresh fruit bunch mill and become the largest producer and exporter around the world [1]. World marketing had shown that Malaysia accounts for 39% of world palm oil production and 44% of world exports [2]. Currently, the demand on palm oil and oleo chemical industries, its production is expected to increase [3]. Unfortunately, along with the palm oil production, wastewater from the processing was also increase. Realizing rapid growth of this sector, it is critical to treat palm oil mill effluent (POME) to an acceptable level before being discharge.

Raw POME is a thick brownish viscous liquid waste with an unpleasant odor and high in colloidal suspension [4]. The wastewater generated from palm oil processing has 95-96% water, 0.6 – 0.7% oil and 4-5% total solids [5] [6]. Due to its high biological oxygen demand (25,000 mg/L), chemical oxygen demand (53, 630 mg/L), oil and grease (8, 370 mg/L) and suspended solid (19, 020 mg/L), its disposal without proper treatment in water bodies has became undesirable [7] [8]. Hence, the palm oil industry has a big responsibility to face it in term of environmental protection, economical viability, and sustainable development.

There are several inventive treatment method developed and applied by palm oil mills to treat POME. The most popular method use is convectional biological treatments of anaerobic or facultative digestion [6]. This conventional wastewater treatment technologies adopted in palm oil industrialized is quite expensive to build, operate and maintain. This is because the biological treatment system requires proper maintenance and monitoring as the bacteria is very sensitive to the changes in the environment. It was to ensure a conducive environment is maintained for microorganisms in which to survive. In addition, attentions from skilled operators as well as the commitment from the management were also required. It is more dangerous when this biological treatment also generates vast amount of biogas which are corrosive and odorous [6]. Unfortunately, these issues were normally ignored by the mill owners.

Currently, many research efforts are going on for development of wastewater treatment that is less costly, easily adaptable and environmental friendly [9] [10]. One of these types of treatment is by using activated carbon. Adsorption-based innovative technology developed with low cost carbonaceous materials showed good potential

[11] [12]. Generally, activated carbon is functionally prepared to exhibit an extended inter-particulate surface area and a high degree of porosity [13] [14]. Moreover, activated carbon is considered excellent adsorbent characteristics in reduction of color, adsorbable organic halides (AOX) and non-biodegradable of such wastewater [12] [15]. The activated carbon is very useful for many purposes including filtration, purification, deodorization, decolorization, purification, and separation [14]. Activated carbons have been produced from carbonaceous raw materials such as coal, lignite, wood, coconut shell, and some agricultural waste products [16]. All of these raw materials are abundant and renewable resources. The effectiveness of activated carbon as an adsorbent depend to its unique properties, large surface area, a high degree of surface reactivity, universal adsorption effect, and favorable pore size [13].

Coconut shell, a hard and thick bony endocarp material, which often presents serious disposal problems for local environments, is an abundantly available agricultural waste from the local coconut industry [17]. Coconut shell which have been neglect of its usage before have been change as activated carbon. The better-quality and low impurities of activated carbon made from coconut shell charcoal (CSC) is because of the high microporosity, high destiny, low attrition loss, intrinsic hardness, low ash content and longer service life of the raw material. Advantageously, CSC is believed to remove the heavy metals in the wastewater [17]. The exchange/sorption properties of coconut shell are due to the presence of some functional groups, such as carboxylic, hydroxyl, and lactone, which have a high similarity for metal ions [18].

The aim of this study was to assess the potential of coconut shell carbon (CSC) in reduction of turbidity and suspended solid from palm oil mill effluent (POME). Purposely, biochar from coconut shell has been used in the present study to see the feasibility of adsorbent under batch operation and accordingly, optimum operating conditions have been worked out for the treatment of palm oil mill effluent.

MATERIALS AND METHODS

Materials

Samples of wastewater were taken from a local palm oil mill in Dengkil, Selangor. Raw palm oil mill effluent (POME) was taken from a sludge pit that had a temperature of around 80°C to 90°C. All of the samples were stored at 4°C to avoid biodegradation due to microbial action. For the analysis and experimental purpose, the temperature of the sample was allowed to reach room temperature.

Fig. 1: The coconut shell charcoal.

Adsorbent use in this study was prepared from shell of coconut. The CSC was supplied by Kekwa Indah Sdn. Bhd. The CSC was produced using steam activation. First the raw coconut shell was carbonized to an intermediate product. Then, it is fed into rotary kiln which reacts with steam at high range temperature between 800°C to 1000°C to enlarge the pore structure to form activated carbon. The diameter of CSC is 1.38 – 3.15 mm with bulk density of 0.5 g/cm^3. Fig. 1 shows CSC that used in this study.

1 M of Hydrochloric Acid (HCl) and 1 M Sodium Hydroxide (NaOH) was used to adjust the pH of the solution.

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Analysis

The suspended solid (SS) analysis was carried out by evaporating the filtrate of the sample to dryness in a weight crucible and then drying it to a constant weight at 105°C. The addition in the weight divide with known volume sample indicated the presence of suspended solids. Turbidity was measured using a turbidity meter (HACH, brand model 2100N). The pH was measured by a pH meter (Eutech instrument). The details of all the analytical methods conducted were based on procedures given in the APHA, Standard Method for the Examination of Water and Wastewater [19]. Each analysis was repeated twice.

Batch mode treatment of wastewater sample

All the experiments were carried out at temperature 25°C in batch mode. The batch experiments were conducted in different beaker of 250 ml capacity and the solution was agitated using Certomat Moll and HK-Orbital benchtop shaker. Adsorption experiments were conducted in different batches for all the experimental conditions like adsorbent treatment time, adsorbent dose, agitation speed and pH of the solution.

The influences of various operating parameters were studied by varying one parameters and keeping others constant. Each beaker was filled with 100 ml of sample having desired pH and agitation speed was initiated. Then, the sample was withdrawn after agitated at a given time and filtered by using filter cloth for the analysis of turbidity and suspended solid.

Effect of treatment time of the adsorbents with the wastewater sample was investigated by agitating 100 ml of sample with 2g adsorbent at different time periods varying from 5 minute to 90 minutes. The pH of the sample was as it original pH and the agitation speed was 150 rpm. The treated sample was withdrawn at pre-determined time intervals, filtered and the residual was analyzed.

After that, the effect of adsorbent dosage on reduction of turbidity and SS was investigated by treated 100 ml of samples with different doses of adsorbent ranging from 1 to 80 g/l; the other conditions were; optimum treatment time, pH 4.2 and agitated at 150 rpm. The samples were agitated for specific time intervals, filtered and the residual is being analyzed. Then, the data for suspended solid were fitted into Freundlich adsorption isotherm [12] [20].

The effect of agitation speed was studied with optimum treatment time and adsorbent dosage, constant pH of 4.2 while the agitation speeds were varied from 70 to 300 rpm. As usual, the pre-determine speed intervals was filtered and residual was being analyzed.

The effect of pH was carried out with optimum adsorbent dosage, contact time, and agitation speed at 150 rpm but varying the pH values from 2 to 8 using 1M NaOH or 1M HCl solution. The solution was stirrer at specific time intervals. Then filtered it and the residual is being analyzed.

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RESULT AND DISCUSSION

Adsorbent treatment time

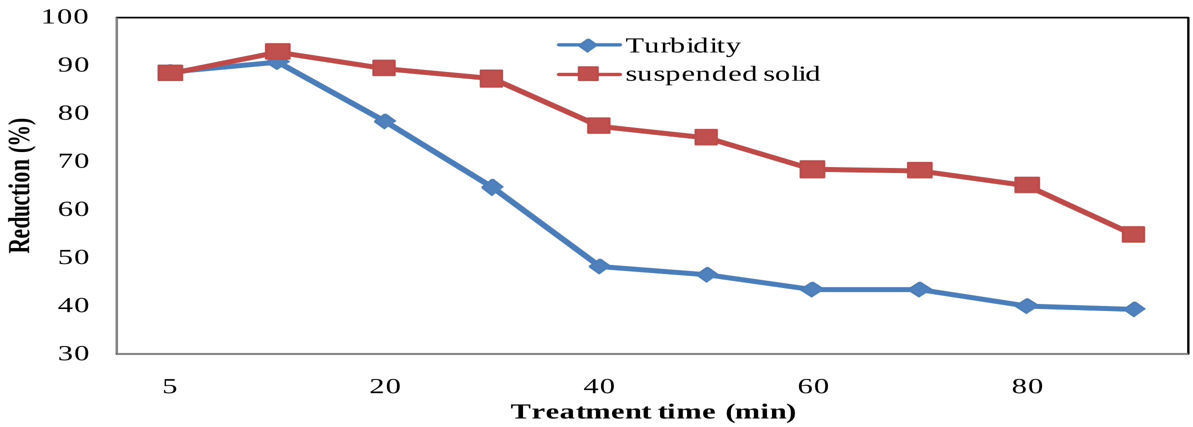

Fig. 2: Effect of treatment time on turbidity and suspended solid using CSC adsorbent. Adsorbent dose: 20g/l, pH: 4.2, and stirring speed: 150 rpm.

The percentage reduction of turbidity, and SS as a function of treatment time with CSC was shown in Fig. 2. The maximum reduction of turbidity and SS was 90.5% and 92.6% respectively after the treatment time of 10 minutes. After 10 minutes, the reduction tends to be decreased as the adsorbent site was towards saturation. This CSC is easily dispersed in the suspension at prolonged mixing like others activated carbon [21]. This situation indicates that the SS which attached to the adsorbents before starts to detach and dispersed again into the suspension. Moreover, due to the high agitation speed will indirectly influence the breakages of flocs as well as attached SS. Turbidity and SS reduction can be seen correlated with each other. 10 minutes of treatment time was a shorter treatment time. Hence, the shorter treatment time can be seen as significant time for economical wastewater treatment plant.

Adsorbent dose

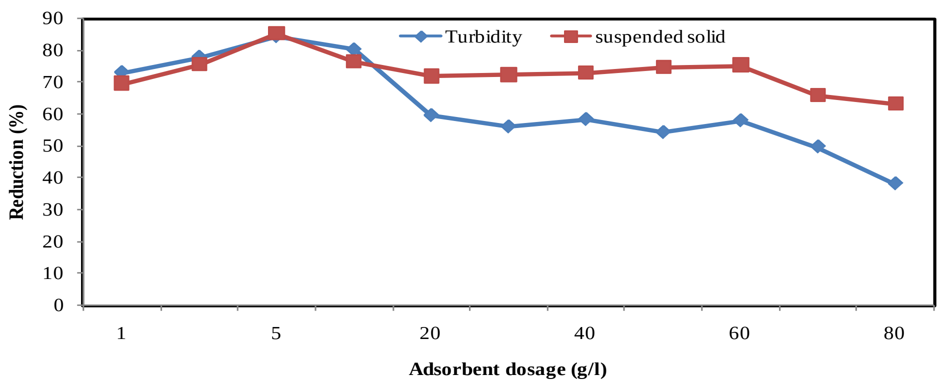

Fig. 3: Effect of adsorbent dose on turbidity and suspended solid using CSC adsorbent. Treatment time: 10 minutes, pH: 4.2 and stirring speed: 150 rpm.

The effect of adsorbent dose on percent reduction of turbidity and SS was shown in Fig. 3. For this batch, the time was kept constant at 10 minutes. Equilibrium was reached corresponding to5g/l of adsorbent dose for CSC with the 84.3% and 85.3% reduction of turbidity and SS respectively. From tabulated data, it's clearly shown that the turbid and SS reduction gravimetrically gives a linear relationship. Fig. 3 present that the colloidal and turbid removal was increased when the adsorbent dosage was increased until 5g/l. However, when the adsorbent dosage was more than 5g/l the reduction percentage of colloidal and turbid was reduced. At high adsorbent dosage of CSC, a sufficient degree of over-saturation occurs to produce a rapid precipitation of large quantity of adsorbent. POME can be treated by using only 5g/l of CSC which can be consider as economically low adsorbent dosage.

The adsorption studies conducted were fixed to Freundlich isotherm [12] [20] in the equation 1 below:

$$\frac{x}{m} = kC_e^{\frac{1}{n}} \qquad (1)$$

Where, x/m (mg/g) was the amount of suspended solid removed (x) per unit mass adsorbent (m), C_e (mg/L) was residual concentration of aqueous solution, k and 1/n were Freundlich constants and measure of adsorption capacity and adsorption intensity respectively.

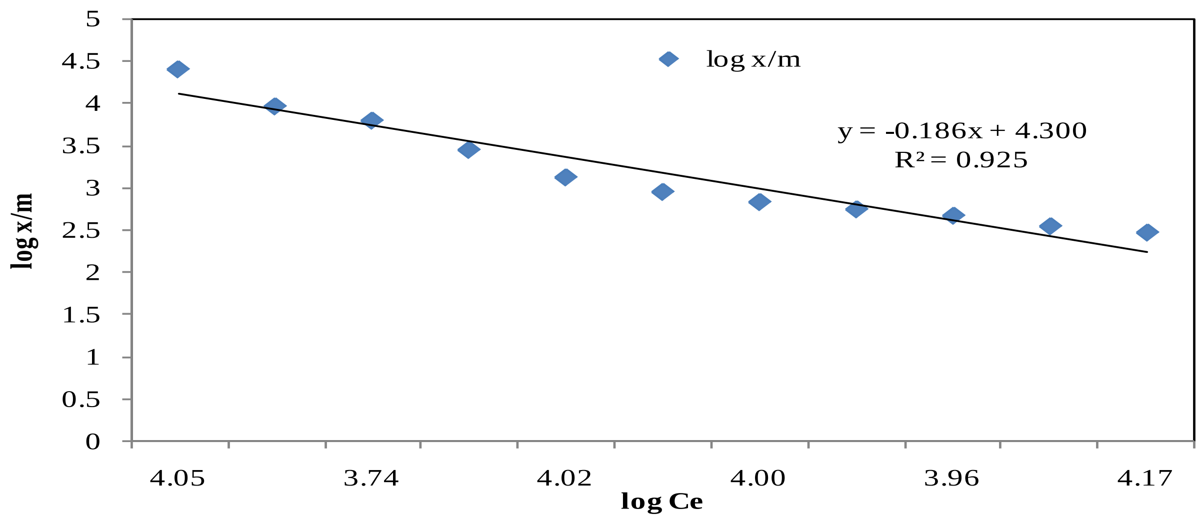

Fig. 4: Freundlich adsorption isotherm for SS reduction by CSC.

The Freundlich isotherm subsequent to the experimental measurement for CSC was plotted on the log scales as shown in Fig. 4. Values of regression coefficient r^2 had been obtained from the linear fit and based on the fit, the respective values of the slope 1/n and intercept on y-axis taken as k were also calculated. From Fig. 4, values of 1/n, k and regression coefficient, R^2 for CSC were -0.186, 4.300 and 0.925 corresponding to suspended solid reduction.

The constant 1/n and k are of definite importance in determining the adsorption capacity of organic pollutant from POME and reduction of SS concentrations by the CSC. It can be seen that the slope 1/n is dependent on the order of the change of reduction of SS concentrations with the adsorbent dose. Meanwhile for k is dependent on the extent of removal of SS by the adsorbents.

Agitation speed

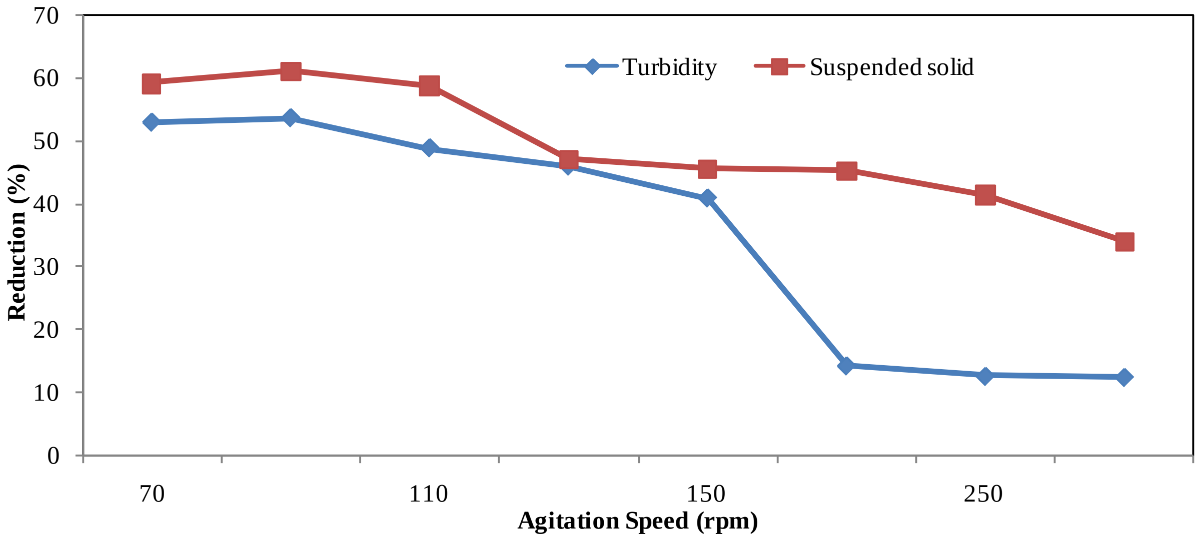

Fig. 6: Effect of agitation speed on turbidity and suspended solid using CSC adsorbent. Treatment time: 10 minutes, Adsorbent dose: 5g/l and pH: 4.2.

An investigation on the effect of agitation speed on % turbidity and SS reduction the speed was kept from 70 rpm to 300 rpm. From Fig. 6, the trend of reduction for turbidity and SS seems to be good. The equilibrium was achieved at speed 90 rpm with 61.2% and 53.8% reduction of SS and turbidity respectively. When the agitation speed was higher than 90 rpm, the reduction of SS and turbid was decreased due to the fact that the loosely attached molecule might re-enter into the adsorbate.

pH

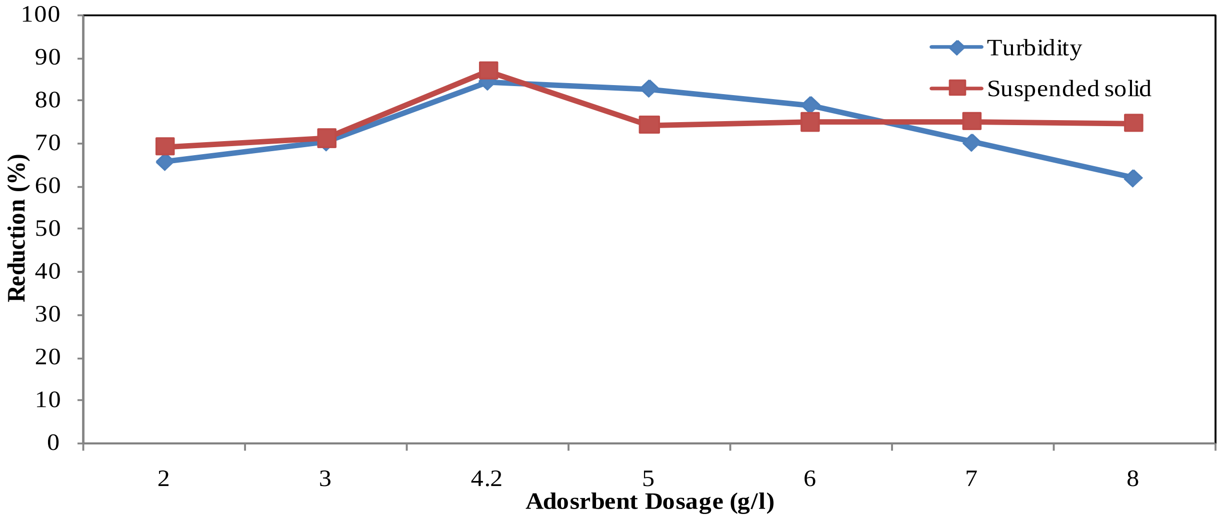

Fig. 5: Effect of pH on turbidity, suspended solid, total solid and total dissolved solid using CSC adsorbent. Treatment time: 10 minutes, Adsorbent dose: 0.5g/100ml and stirring speed: 90 rpm.

A study on the effect of pH was necessary to determine the optimum pH condition for the treatment. It was imperative to determine the optimum pH, because pH not only affects the surface charges of the adsorbent but also the degree of ionization during reaction [21]. Fig. 5 shows the effect of pH on the adsorption capacity of CSC and hence turbidity and SS reduction from POME. The optimum pH for maximum adsorption of organic impurities, SS and turbidity from POME by CSC was 4.2. From Figure 5, its show that at the original pH value of POME (4.2), the reduction of turbidity and SS was very satisfying and achieved of 84.3% and 86.7% reductions. This encouraging and make the process more simple when the pH adjustment is unnecessary under real-process treatment conditions for removing the colloidal. At this acidic condition, the isoelectric point between the colloidal in POME and adsorbent has been achieved and indirectly enhances the adsorption capability. Moreover, at this condition the concentration of H^+ ion and negative charge density are relatively very small compared to the situation under more acidic or higher alkali conditions.

When the pH of the POME was more than 4.2, the adsorbent reach its saturation stage. It was a consequence from the adsorption process at this range of pH which was very unstable due to the characteristics of POME. Characteristics of POME will change drastically with the change of pH [21].

CONCLUSION

It was study that, using CSC adsorbent was effectively reduced the turbidity and SS from POME. Adsorption of turbidity and SS was found to be dependent on treatment time, adsorbent dose, pH and stirring speed. Adsorption data from this study was well fitted to Freundlich Adsorption Isotherm. This adsorbent that made up from coconut shell can be one of the alternatives as pre-treatment in POME treatment. Moreover, it is more economical and environmental friendly without using any pH adjustment to reach the equilibrium stage.

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