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# The Effectiveness of Banana Stem, Pineapple Leaf and Sugarcane Peel as Bio-sorbent in Wastewater Treatment

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**Abstract**: Banana stem, pineapple leaf and sugarcane peel are an agricultural waste whereas an abundance of worthless banana stem, pineapple leaf, and sugarcane peel can be considered a rise in trash. The purpose of this study was to look into the potential of banana stem, pineapple leaf, and sugarcane as bio-sorbents in palm oil mill effluent (POME) treatment, in order to address the growing amount of banana stem, pineapple leaf, and sugarcane peel as agricultural waste. In this research, the removal of turbidity and reduction of chemical oxygen demand (COD) from palm oil mill effluent (POME) was investigated and explored with the adsorption process performance research. From previous research, banana stem has the ability to adsorb heavy metal such as copper ion, zinc ion and iron ions which exist in palm oil mill effluent (POME). The optimum pH for turbidity was found at pH 6 to 11 while COD at pH 10 to 11. For the optimum dosage for turbidity was found at 80 mg/L to 160 mg/L while COD at 120 mg/L to 200 mg/L. Based on the results, it can assume that banana stem, pineapple leaf and sugarcane peel bio-sorbents can be an alternative method in palm oil mill effluent (POME) treatment.

**Keywords**: Banana Stem, Bio-sorbents, Palm Oil Mill Effluent (POME) Treatment

## 1. Introduction

Banana is also a major tropical fruit in Malaysia's agricultural business. Accordingto the Malaysian government statistics report, around 29 270 hectares of banana were planted in 2012, with a total yield of roughly 29 4530 metric tonnes[1]. Therefore, there is an excess of banana stem each time the banana fruit was harvested in a certain plantation area. Pineapple (Ananas comosus) is a fruit that has already been produced in Asia, Africa, and America and is consumed either organically or as a processed product. After harvesting the crop, the pineapple leaf becomes leftover, which is usually burned to eradicate fungus andother parasites, composted, or just stacked to decay [2]. As a result, pineapple leaf may be used as a bio sorbent for adsorption treatment since it is a readily accessible biodegradable agricultural waste.

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In order to reduce the abundance of the bio-sorbents, this study aims to investigate the effectiveness of banana stem, pineapple leaf and sugarcane peel to be used as bio-sorbent in palm oil mill effluent (POME) treatment. This study will investigate the performance of bio-sorbents to reduce the chemical oxygen demand (COD) value and other parameters of the palm oil mill effluent (POME) through adsorption. Adsorption has already been used since ancient years which for treatment of industrial wastewater from organic pollutants and meet the great attention from the researches also eliminating turbidity from the wastewater treatment. Research regarding the capabilities of banana stem, pineapple leaf and sugarcane peel bio-sorbent will be study according to few parameters which are removal turbidity and reduction of chemical oxygen demand (COD) of wastewater because all of those parameters are important in POME treatment by getting the optimum ph and dosage.

### 1.1 Objectives

This project was aimed to prepare bio-sorbent from different agricultural waste for the palm oil mill effluent (POME) treatment. The characterization of bio-sorbent that prepare from natural bio-sorbent was investigated in this project. The effect of the performance of agricultural waste to remove turbidity and reduce chemical oxygen demand (COD) will also be studied.

### 1.2 Scope of study

This project focused on the preparation of bio-sorbent from agricultural waste that are banana stem, pineapple leaf and sugarcane peel. Fourier Transform Infrared (FTIR) also used to characterize the bio-sorbent that prepare from natural bio-sorbent. Data about the performance of bio-sorbents which are banana stem, pineapple leaf and sugarcane peel with the optimum pH and optimum dosage will be check on POME treatment quality of chemical oxygen demand (COD) and turbidity.

## 2. Methodology

These consists procedures for the synthesis of agricultural waste of different dosage and pH of bio-sorbent used for the palm oil mill effluent (POME) treatment by adsorption process. Therefore, the performance of bio-sorbents in to get optimum pH and dosage of bio sorbent, the treated palm oil mill effluent (POME) wastewater will be test through turbidity test and chemical oxygen demand (COD) test.

### 2.1 Materials and Apparatus

The main materials required were bio-sorbents and palm oil mill effluent (POME) for the adsorption process treatment. The apparatus and equipment used in the adsorption process are turbidity meter, Fourier Transform Infrared (FTIR) and pH Meter.

### 2.2 Adsorption process

A magnetic stirrer was used to aid in the adsorption process [3]. The initial condition such as pH, turbidity and chemical oxygen demand (COD) was taken before start the adsorption process. The percentage reduction of several characteristics such as turbidity and chemical oxygen demand (COD) of POME is then calculated.

### 2.3 Turbidity test

Turbidity meter was used to measure using portable turbidity meter [4]. The principle is based on a comparison of the intensity of light scattered by the sample. The turbidity meter was switch on and will be standardized 100 NTU. The sample of wastewater was placed into the turbidity meter and the value was shown in NTU unit. The percentage removal was calculated as follows:

$$Turbidity\ percentage\ removal \approx \frac{A-B}{A} \times 100 \quad Eq. 1$$

where A is turbidity of raw coolant wastewater (NTU), B is turbidity after treatment (NTU), and A is turbidity of raw spent coolant wastewater (NTU).

2.4 Chemical Oxygen Demand (COD) Test

The chemical oxygen demand (COD) test was measured using closed-reflux titration method [5]. Chemical oxygen demand (COD) refers to the amount of oxygen required to oxidize the organic compounds in wastewater sample to carbon dioxide and water. The determination of COD concentration (mg/L) for the titrimetric method was calculated as follows:

$$COD, \frac{mg}{L} = \frac{(a-b)(M) \times 8000}{Sample\ size, mL} \qquad Eq. 2$$

where a is volume of FAS used for blank (mL), b is volume of FAS used for sample (mL) and M is molarity of FAS, N (0.1 N).

2.5 Fourier Transform Infrared (FTIR)

The Fourier Transform Infrared Spectrophotometer used to determine the presence of different functional groups in the sample. The wavelength being adjusted to 4000 to 400 $cm^{-1}$. The graphs of FTIR spectrum were plotted to determine each functional group that appeared on the surface of the samples [6].

## 3. Results and Discussion

The study on the banana stem, pineapple leaf and sugarcane peel bio-sorbent were investigated and analyzed based on their capabilities to remove turbidity and reduce the chemical oxygen demand (COD) from untreated of palm oil mill effluent (POME). Data obtained were collected and analyzed to show the effectiveness of the bio-sorbents to be use in palm oil mill effluent (POME) treatment by optimum pH and dosage.

3.1 Removal of Turbidity with optimum pH

The findings of the experiment on the ability of banana stem, pineapple leaf and sugarcane peel bio-sorbent to remove turbidity were analyzed and compared to observe the bio-sorbents adsorbing characteristics. Figure 1 shows an average value of removal percentage by banana stem, pineapple leaf and sugarcane peel bio-sorbent.

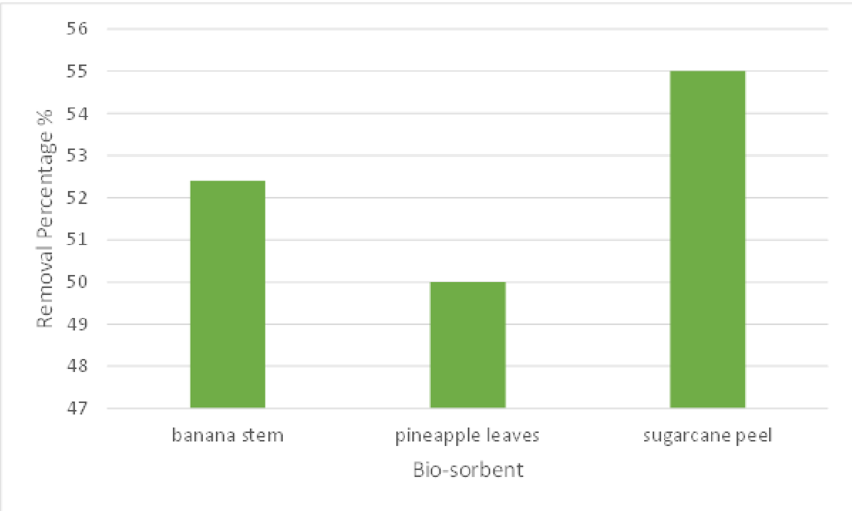

**Figure 1: Average value of Removal Percentage by Banana Stem, Pineapple leaves and Sugarcane Peel Bio-sorbent**

Based on the figure 1 above, it shows that all studies shows that sugarcane peel were able to remove in the highest removal percentage of turbidity rather than banana stem and sugarcane peel in each of the wastewater sample used. In terms of turbidity, sugarcane peel has the potential to lower the turbidity value compared to banana stem from other research because sugarcane peel also can adsorb tiny particles in the secondary effluent, which are the primary causes of turbidity [7]. As sugarcane peel adsorb the smaller particles in the wastewater sample, the smaller particles will settle down, resulting in a lower turbidity measurement. From the result above, it can assume that the decrease in turbidity value was caused by tiny particles settling down, which might also lead to change in color [8].

During the adsorption process, pH value can cause difference in performance for the bio-sorbents. The optimum pH value is obtained from the minimum point of the graph or the lowest turbidity value. Due to that, it can assume that sugarcane peel and banana stem are capable to adsorb smaller particles in the wastewater to reduce turbidity value [9]. Prior study found that banana stem had the best turbidity removal in natural and slightly alkaline pH environments in the range of pH 6 to pH 11 [10]. The removal percentage of turbidity at different pH values are shown in Figure 2.

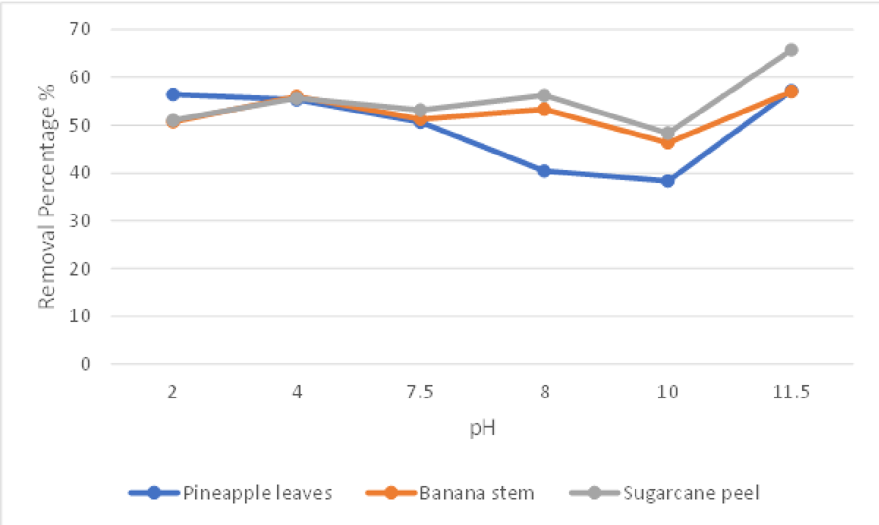


**Figure 2: Effect of pH on Different Bio-sorbent**

The banana stem and sugarcane peel powder have a strong potential to act as a bio-sorbent in the wastewater treatment process. Because the turbidity level in palm oil mill effluent (POME) was high, treatment with banana stem and sugarcane peel bio-sorbent might minimize the turbidity level. Thus, banana stem and sugarcane peel bio-sorbents may be suitable for use in the treatment of palm oil mill effluent (POME).

3.2 Removal of Turbidity with Optimum Dosage

The removal percentage of turbidity at different dosage values are shown in Figure 3. Generally, higher dosage of bio-sorbent will result in higher removal percentage.

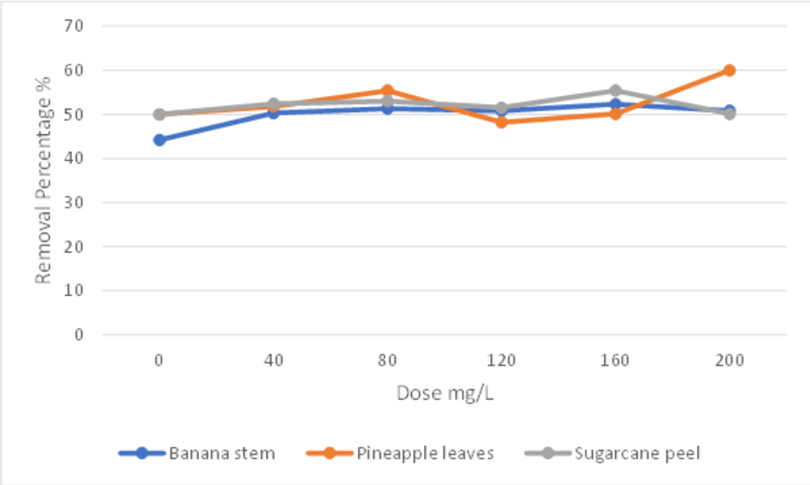


**Figure 3: Effect of Dosage on Different Bio-sorbent**

Figure 4.11 depicts the turbidity removal and adsorption activity of all-natural bio-sorbents at various dosages. For banana stem, at 160 mg/L maximum removal was obtained while sugarcane peel and pineapple leaves achieve maximum removal percentage at 200 mg/L. A prior study found that banana stem had the best turbidity removal in natural and slightly at dosage in the range of 80 mg/L to 160 mg/L.

3.3 Reduction of Chemical Oxygen Demand (COD)

Previous research has shown that banana stem can remove or reduce the chemical oxygen demand (COD) value of wastewater with banana stem [11]. Data obtained from the experiment regarding the reduction of chemical oxygen demand (COD) for treatment with banana stem, pineapple leaves and sugarcane peel bio-sorbent were shown in Figure 4.

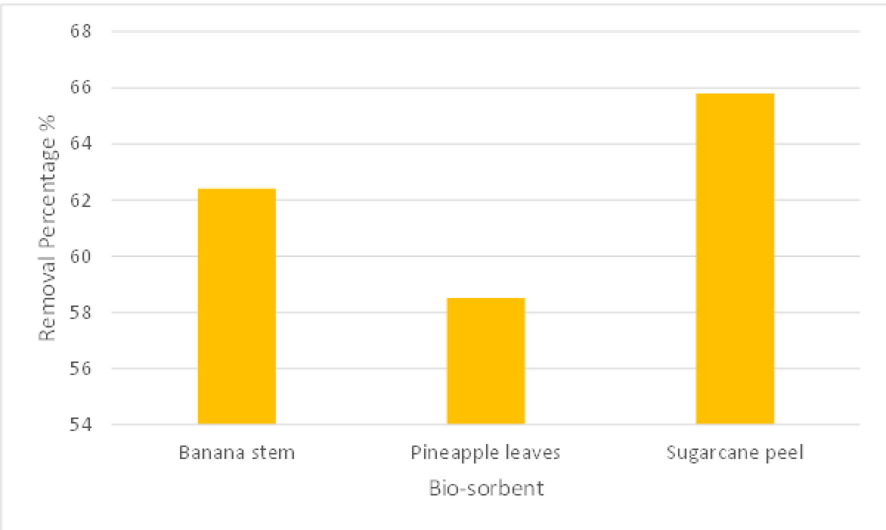


**Figure 4: Average value of Removal Percentage by Banana Stem, Pineapple leaves and Sugarcane Peel Bio-sorbent for Reduction of COD**

All data obtained suggest that treating the wastewater using banana stem, pineapple leaves and sugarcane peel has a favorable influence on the chemical oxygen demand (COD) value of the wastewater. Except for pineapple leaves, which have a removal rate of only 58.5%, some of this data indicates removal rates of more than 60.00% of COD. However, in certain investigations, the wastewater final chemical oxygen demand (COD) value after treatment appears to be higher than the standard of Department of Environment's regulations (DOE). Despite this, pre-treatment using banana stems, sugarcane peel and pineapple leaves can still be used before the wastewater is treated further before discharge [12].

From previous research by using Fourier Transform Infrared (FTIR) analysis revealed that have functional groups in banana stem, pineapple leaves and sugarcane peel. In that research, banana stem is stated to contain hydroxyl group of (O-H), primary amine (N-H) and carboxylic acid group (-COOH) [13]. From that, banana stem suitable as bio-sorbent which can reduce the chemical oxygen demand (COD) and the functional group helps the banana stem and other bio-sorbent to adsorb towards organic pollutants and phenolic compounds [14].

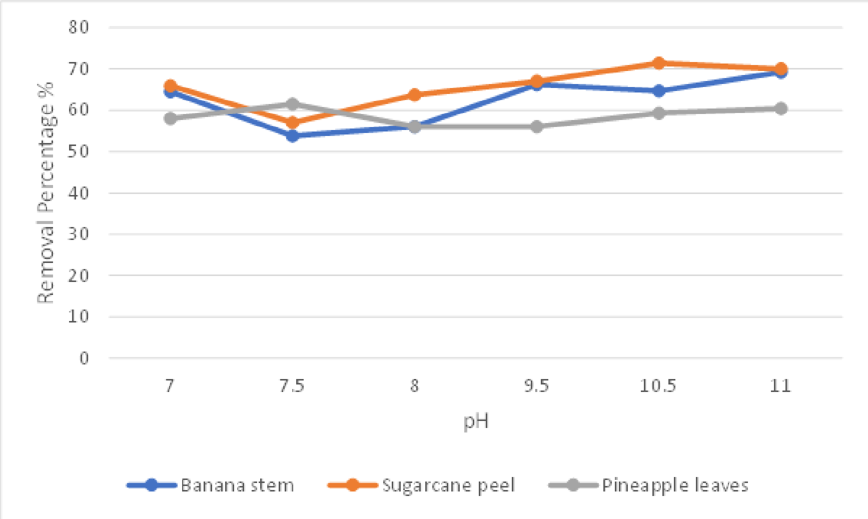


**Figure 5: Chemical Oxygen Demand (COD) Percentage Removal against pH**

The efficacy of the banana stem, pineapple leaves and sugarcane peel bio-sorbents can also affect the treatment factors or conditions, such as pH value and dosage [15]. The effectiveness of bio-sorbent to reduce chemical oxygen demand (COD) is expected to be optimum at pH values ranging from 10 to 11. This was shown in the Figure 5 where it shows that the chemical oxygen demand percentage removal is at the highest value when the pH is at 10 to 11. As a result, it can assume that banana stem, pineapple leaves and sugarcane peel bio-sorbent perform best near neutral range of pH value.

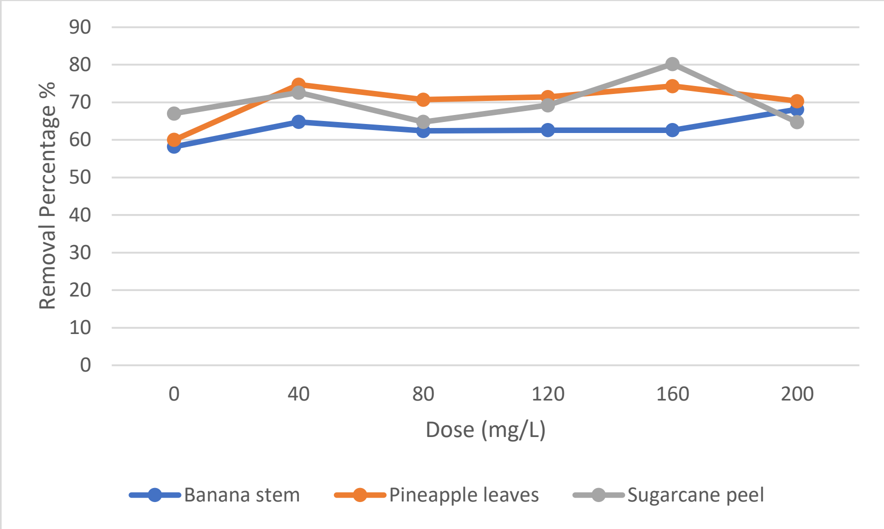


**Figure 6: Effect of Various Bio-sorbent Dosages on COD Removal**

Next conditions or parameters that can affect the adsorbing capabilities of banana stem, pineapple leaf and sugarcane peel bio-sorbents is dosage between the bio-sorbent and wastewater. Based on the data obtained from the experiment that shown in Figure 6, the chemical oxygen demand (COD) removal percentage were highest when the dosage was at the range 120 mg/L and 200 mg/L. When the dosage at 80 mg/L, the removal percentage of chemical oxygen demand (COD) by the sugarcane peel, pineapple leaves and banana stem bio-sorbent very low. This might be due to dosage used too small and not able to trap the COD contained in the wastewater.

As a result, the ability of bio-sorbents from banana stem, pineapple leaf and sugarcane peel to lower the chemical oxygen demand (COD), it can be stated that the used of banana stem, pineapple leaf and sugarcane peel as bio-sorbents can be employed for palm oil mill effluent (POME) treatment. This is due to the fact that the chemical oxygen demand (COD) value of palm oil mill effluent (POME) was extremely high, ranging between 15 000 and 100 000 mg per liter and the average of chemical oxygen demand (COD) value was around at 51 000 mg per liter [16].

As a result, lowering the chemical oxygen demand (COD) value of palm oil mill effluent (POME) is critical. Because banana stem and sugarcane peel bio-sorbents were capable of reducing chemical oxygen demand (COD) and turbidity value, which are highly essential in palm oil mill effluent (POME) treatment, it can be considered to have the potential to be utilized in POME treatment. In terms of process parameters, the optimal pH range of turbidity 6 to 11 while COD is 10 to 11. The optimal bio-sorbent dose between bio-sorbents and wastewater for turbidity is between 80 mg/L to 160 mg/L while for COD is between 120mg/L to 200 mg/L.

## 4. Conclusion

To summarize, the possibility of repurposing banana stem, pineapple leaf and sugarcane peel waste as bio-sorbents was investigated, and it was discovered that they were effective in removing turbidity and reducing chemical oxygen demand from palm oil mill effluent (POME). FTIR was used to characterize the morphology and functional group of banana stem, pineapple leaves and sugarcane peels. The adsorption ability of banana stem, pineapple leaf and sugarcane peel were studied using several factors or parameters, including optimum pH and optimum bio-sorbent dosage in order to remove turbidity and reduction of chemical oxygen demand (COD).

These three agricultural wastes have potential as bio-sorbent to be use in palm oil mill effluent (POME) treatment. The ability of bio-sorbents to remove turbidity and remove chemical oxygen demand (COD) of wastewater was demonstrated. As a result, the untreated wastewaters chemical oxygen demand (COD) value can be reduced. Adsorption of heavy metal ions and phenolic compounds can also be aided by functional groups such as hydroxyl (O-H) and carboxylic acid (-COOH). Overall, banana stem and sugarcane peel waste exhibited better selectivity towards turbidity and chemical oxygen demand adsorption.

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