THE POTENTIAL OF PALM OIL MILL EFFLUENT (POME) AS A RENEWABLE ENERGY SOURCE

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ABSTRACT

The expanding of oil palm industry has given a significant benefit to the economic growth and country development. However, it has also contributed to environmental problems due to the production of huge quantities of waste and by-products. Palm oil mill effluent (POME) is a liquid discharge from the palm oil milling process. POME without proper treatment could be harmful to environment because it emitted greenhouse gas emissions into the atmosphere. Therefore, due to its high organic carbon content, POME has currently been applied to generate biogas. This study aims to measure the physicochemical characteristics of untreated POME and the potential of POME as renewable energy. The physicochemical characteristics of raw POME such as chemical oxygen demand (COD), ammonia (NH₃N), dry matter (DM) content and heavy metals were also measured and compared with the regulatory discharge limits. Converting POME to biogas can produce energy which save a huge source of renewable energy as well as reduce the environmental impacts of palm oil production.

Keywords: Palm oil mill effluent (POME), physicochemical characteristic, biodegradable, renewable energy, Malaysia

1. INTRODUCTION

The Malaysian palm oil industry has grown greatly in the recent years to become one of the largest palm oil exporters and producers in the world, thus contributes tremendously towards the economy of the country [1]. Therefore, it is important for the palm oil industry to be sustainable to increase its long-term profitability and sustainability. This industry supplied a huge number of byproducts such as empty fruit bunch (EFB), palm fiber and shell that are readily available to be used as energy source [2,3]. The flow chart of a typical milling process in Malaysian palm oil mill is shown in Figure 1. The extraction of palm oil involves several processing stages which are sterilization, stripping, digestion, pressing, clarification, purification and vacuum drying [4,5]. The most standard and typical way of extracting palm oil in Malaysia is the wet process of palm oil milling [6,7]. A large quantity of water is required at certain stage processes and more than half of this water amount ends up as palm oil mill effluent (POME).

The number of palm oil mills in Malaysia was increasing in the past few years, from about 10 mills in 1960 to 426 operating mills in 2011 [17]. However, the sustainability of palm oil production has always been questioned. This is because of the controversy that palm oil plantation causes severe negative impacts on environment such as deforestation and greenhouse gas (GHG) emissions due to over exploration of peat land for oil palm plantation [8,9]. Palm oil mills also contribute to the environmental degradation due to the production of POME generated from the palm oil milling process. Nevertheless, POME is identified as a potential source for generating renewable energy through anaerobic digestion, which give a great advantage to the palm oil industry. Accordingly, the utilization of POME as substrate to produce biogas become popular nowadays especially in Malaysia and Thailand [10,11]. In this study, the physicochemical characteristics of raw POME were measured. The physicochemical characteristics provide a useful and necessary information for the management of POME treatment and determination of the potential of biogas production originated from POME.

2. MATERIAL AND METHODS

2.1 Sampling method

POME samples were collected from Seri Ulu Langat Palm Oil Mill, Dengkil, Selangor. The mill’s main activities were for starch and vegetable fats and oils manufacturing. The samples were taken from the pipeline of fresh fruit bunch (FFB) sterilization process. The POME samples were kept in Schott bottle and stored at 4 ºC for later use in order to prevent microbial decomposition.

2.2 Apparatus and operation

A laboratory analysis was done to determine the physicochemical characteristics of POME such as dry matter (DM), organic dry matter (ODM), nutrient analysis, heavy metals analysis, chemical oxygen demand (COD), ammonia test and carbon to nitrogen ratio analysis. The percentage of DM (%) and ODM (%) content was determined by using the following formulae according to VDI 4630, 2006 guideline:

\[ DM = \frac{\text{Dry sample weight (g)}}{\text{Wet sample weight (g)}} \times 100 \]

\[ ODM = \frac{(\text{Dry sample + porcelain weight (g)}) - (\text{Dry porcelain + ash weight (g)})}{\text{Wet sample weight (g)}} \times 100 \]

\[ \text{Dry sample weight (g)} = \text{Dry sample weight (g)} \]

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2.3 Analytical methods

Nutrient analysis was conducted by UNIPQ Sdn. Bhd., UKM. The protein content was determined using in house method No. STP/Chem/A03 based on AOAC 16th Ed. 981.10 and fat content was determined using in house method No. STP/Chem/A02 based on AOAC 16th Ed. 991.36. Total carbohydrate content was determined using in house method No. STP/Chem/A06 based on Proarena Food Analysis: Theory and Practice, 2nd Ed. (pg 637). In house method No. STP/Chem/A05 based on AOAC 16th Ed. 923.03 and No. STP/Chem/A04 based on AOAC 16th Ed. 950.46 were used to determine ash and moisture content, respectively. Energy content was measured using in house method No. STP/Chem/A01 based on Pearson’s The Chemical Analysis of Foods (6th Edition, page 578). Inductively Coupled Plasma Mass Spectrometry (ICP-MS) was used to determine the concentration of heavy metal, while Hach DR 6000 spectrophotometer was used to determine the COD by HACHReactor Digestion Method. The ammonia-nitrogen analysis was also conducted by using Hach DR 6000 spectrophotometer, following the Nessler method. The C/N ratio was determined using CHNS analyser.

3. RESULTS AND DISCUSSION

Table 1 shows the laboratory analyses results on the physicochemical characteristics of raw POME.

Table 1: Physicochemical characteristics of raw POME

| Parameter                  | Unit  | POME |
|----------------------------|-------|------|
| pH                         |       | 4.3  |
| Temperature                | °C    | 68.2 |
| Ammonia Nitrogen (NH3/NH4) | mg/L  | 290  |
| Chemical Oxygen Demand (COD)| mg/L  | 4.667 |
| Carbon to Nitrogen (CN) ratio | mg/L  | 4.9000 |
| DM                         | %FM  | 6.73 |
| ODM                        | %DM  | 94.90 |
| Heavy Metals               |       |      |
| Magnesium, Mg              | mg/L  | 622.092 |
| Calcium, Ca                | mg/L  | 57.33 |
| Phosphorus, P              | mg/L  | 124.12 |
| Potassium, K               | mg/L  | 3.335.083 |
| Nutrient                   |       |      |
| Protein                    | g/100g| 0.83 |
| Fat                        | g/100g| 0.71 |
| Carbohydrate               | g/100g| 1.5 |
| Ash                        | g/100g| 0.65 |
| Moisture                   | g/100g| 96.32 |
| Energy                     | kcal/100g | 16 |

The three major operations that generate POME include sterilizing fresh fruit bunch (FFB), clarifying extracted crude palm oil (CPO) and empty fruit bunch (EFB) processing. POME is a thick and brownish liquid with high solids, oil and grease, COD and BOD values [10,11]. Fresh POME is hot with temperature of 68.2 °C and pH 4.3 (acidic) (Table 1). Although POME is a non-toxic waste, discharging untreated POME into water bodies can adversely affect the ecology of aquatic by depleting the dissolved oxygen (DO) content because POME contains high chemical oxygen demand (COD) (40,667 mg/L) (Table 1). POME is well known for its high COD value due to its fat contents [12]. POME also contains a significant number of nutrient elements (e.g. Mg, Ca, P, K) which are essential for plant growth. The contents of dissolved constituents such as high concentration of protein, fat, carbohydrate and minerals could be converted into useful materials using microbial processes [13].

POME physicochemical characteristics might be slightly different as from process studies. The quality of POME might be affected by the time of sample withdrawal and also due to the palm oil production processes in the mills and the quality of the FFB [15,16]. Therefore, the experiments were repeated three times for all analyses to obtain average result in order to minimize the differences in the characteristic of POME. Approximately 0.7 m3 of POME is generated for every ton of fresh fruit bunch (FFB) processed [21,17]. Every ton of POME can generate about 28 m3 of biogas. First, 2.4 ton of methane gas can be derived in a year which is equivalent to 3.4 million litres of diesel and the estimated energy generated is 13,600 MWh of electricity.

In Malaysia, about 85% of POME treatment system is based on conventional biological treatment methods of acidification, anaerobic, facultative and aerobic digestion [4,18]. Anaerobic digestion process is a suitable treatment method for rapid disintegration of organic material to produce biogas that can be utilized for electricity and as energy source [19,20]. However, ponding systems in biological treatment methods is quite inefficient due to the high BOD load and low pH of POME as well as colloidal nature of the suspended solids in the POME [12]. In fact, this method also has some disadvantages such as large area of land is needed, relatively long hydraulic retention time (HRT) and difficulty in collecting and utilizing the methane generated which results in harmful effect on the environment. Hence, it is vital to provide a better technology that can overcome all obstacles in the POME treatment [21].

4. CONCLUSION

Exploiting organic wastes as source of energy seems a promising alternative for future’ generation of energy. One of the main wastes in Malaysia is POME and it can be concluded that POME could be a good source for generating bioenergy due to its high organic contents. Since there were abundant amount of POME were generated in the mills, it would be the most reliable renewable energy source. However, a proper POME treatment management is crucial to ensure a sustainable process in palm oil milling, besides protecting the environment. Thus, palm oil industry will continuously contribute a significant benefit to Agro-based industry and social economic for Malaysia.

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