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Comparative Study on Characterization of Malaysian Palm Oil Mill Effluent

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Abstract

The characteristic study on palm oil mill effluent (POME) was analyzed and compared with Malaysians previous studies. Since a long time, necessary and vital information for a proper POME treatment plant design and monitoring purposed will be provided by the characterization of POME. The POME is obtained from palm oil mill of, Malpom Industries Sdn. Bhd, Nibong Tebal, Pulau Pinang. Raw samples were collected and analyzed for ten parameters. The average values of parameters obtained are such as BOD (10,197mg/L), COD (50,500mg/L), total solid (31,533mg/L), suspended solids (4,007mg/L), oil and grease (15,800mg/L), ammonia nitrogen (613mg/L), pH (5.32), temperature (54^{o}C), volatile suspended solid (3,657mg/L) and dissolve oxygen (0.47mg/L). The results indicated that the COD and TS parameters of POME from Malpom Industries Sdn. Bhd, Nibong Tebal was within the ranges as compared with previous studies, while BOD, suspended solid, total nitrogen and temperature values were considered low compared with previous studies but the values of pH, oil & grease were otherwise higher.

Keywords: POME, BOD, COD, TS, Characterization,

Introduction

Malaysia is the second largest exporter of palm oil in the world after Indonesia. In Malaysia and Indonesia, there are over four-fifths of world's palm oil exports are produced. In year 2010, the number of palm oil products exportation was rocketed to achieve 16.5 million tones. Table-1 and figure-1 shows the world palm oil production (Malaysian Palm Oil Board, MPOB) [1]. Palm oil is assumed as one of the most important economic sources in the nation and contributed to the remarkable rise in the Malaysian's GDP[2].

Table-1
2008 World palm oil production[1]

Countries	Tones (x103)	% Share
Indonesia	19000	44.5
Malaysia	17735	41.3
Thailand	1160	2.7
Nigeria	860	2.0
Columbia	800	1.9
Others	3250	7.5

Mechanical process is applied in order to ease the extraction of crude palm oil from fresh fruit bunches. The most standard in Malaysia and typical way of extracting palm oil has adopted by wet palm oil milling process[2]. There are several stages of processing the extraction of palm oil. The process is through operational processes such as sterilizing, striping and threshing of bunches to free the palm fruit[3]. Subsequently process the crude oil is extracted from the digested palm fruit by pressing and purification. Unforgettably, large quantities of water are required at certain stage processes. While the other operational processes in the palm oil mills produce wastes load in the form of gaseous emissions from boilers and incinerators, solid wastes materials and by-products such as empty fruit bunch, potash ash, palm kernel, fiber and shells and liquid waste. During the process, more than 50% of the water will be discharged to the environment as palm oil mill effluent (POME), while the rest are lost as the way of steam in the boilers blow down, wash water and leakage [4].

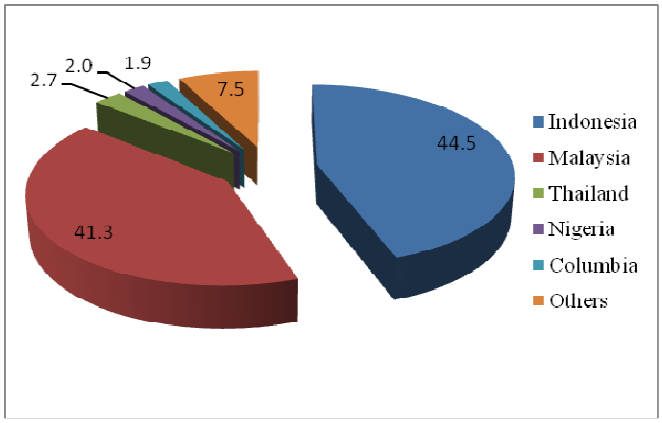

Figure-1
2008 World palm oil production[1]

Undeniably, the oil palm industry and its processing affecting the level of our environment and it may contribute to the alarming rise in the environmental pollution. Plus, negative impact of the environment also caused by palm oil mill effluent.

This industry has been identified as one of the generating of the largest pollution load to rivers in whole country[5]. POME is a thick brownish viscous liquid waste which is non toxic but has unpleasant odor which contains soluble materials that may have a significant impact on the environment. The composition of POME are mainly water, oil, suspended solid, dissolved solid and sand. In year 2008, where approximately 53 million tones of POME were generated in Malaysia[6].

Due to that environmental impact factors, industries should preserve the sustainability of environmental for future generation. There is always a need for concern over the protection and management of water resources. The regulation of effluent standard by the government stated under the Environmental Quality Act, 1974 provides the legal basis for environmental management in general and water pollution control. In 1975 the establish of the department of environment (DOE) and in 1977, DOE announced standards for the quality of POME discharge into watercourses that became increasingly stringent as presented in table- 2[7]. POME of palm oil mills should be treated well before discharging it into streams and rivers. The final effluent samples need to follow the standard methods just then the results are required to be reported to the Department of Environment, Malaysia. Any change in the natural quality of water resources may interrupt the equilibrium of ecosystem[8]. A bad criticism is exerted or expelled to all countries in the entire world as a result of their less attention to the environmental impact issue of economic activities. Thus, even as benefit from profitable the plantation commodity, but harmful environmental impact from this industry cannot be neglected. POME should be treated properly to reduce the impact of POME to the environment before being discharged into watercourses.

Currently, one of the challenging problems faced by Malaysia and many countries in the world is how to manage all type of wastes especially liquid wastewater. Many researchers around the world have studied the characteristics and treatments of various type of liquid wastewater, including synthetic wastewaters [9.10.11]. Oil palm industry needs to conduct a characteristic study on POME because the characterization would provide the necessary information for a proper POME treatment plant design and monitoring purposed. Thus, in this study comparing comparison of the characteristics of POME between the current and previous studies are conducted. The POME characteristics from previous research data are presented in table-3.

Table- 2
Parameters limits in respective standard discharge by the Malaysian Department of the Environment[7].

Parameter	Units	Standard limit
Biochemical oxygen demand (BOD_5)	mg/l	100
Chemical Oxygen Demand (COD)	mg/l	-
Total solid	mg/l	-
Suspended solids	mg/l	400
Oil and Grease	mg/l	50
Ammonia nitrogen	mg/l	150
Total nitrogen	mg/l	200
pH	-	5-9
Temperature	^{o}C	45

Table-3
Measured Parameter of Malaysian POME from Previous Characteristic Studies

Parameters	Ma and Ong[13]	Ahmad et al.[14]	MPOB[15]	Zinatizadeh et al.[16]	Wu et al.[17]	Vijayaraghavan, K., et al.[18]	Wood, et al.,[19]; Wong, et al.,[20]
BOD_5	25 000	25 000	25 000	22 700	-	25,545	21 500-28 500
COD_{Cr}	-	50 000	50 000	44 300	70 900	55,775	45 500-65 000
TS	-	40 500	45 000	-	-	-	33 790-37 230
SS	19 000	18 000	18 000	19 780	25 800	18,479	15 660-23 560
O&G	8 000	4 000	4 000	4 850	-	8,020	1 077-7 582
TN	770	750	750	-	-	711	500 - 800
pH	4.5	4.7	4.7	4.05	4.52	3.4-3.6	4.15 - 4.45
Temp (^{o}C)	80-90	-	-	-	-	83-85	-
VSS	-	-	-	-	-	-	27 300-30150

(All parameters in mg/L, except pH)

Material and methods

Palm oil mill effluent (POME) is acquired from local palm oil industry, Malpom Industries Sdn. Bhd, Nibong Tebal, Pulau Pinang, is chosen for the case study. Raw wastewaters from palm oil mill processing are selected for sampling. Before start the sampling works, the location of the sampling point was decided carefully. The point is located at the position before the wastewater flows into the POME treatment plant. POME samples are collected and kept in polyethylene containers which are closed tightly and transported to laboratory in order to prevent the wastewater from undergoing biodegradation due to microscopic organism action, POME is preserved at a temperature less than 4^0C, but above the freezing point. The sampling works are repeated for 15 batches and a series of tests are carried out in a period of three months.

This study involves two main methods which are field measurement and laboratory experiments. Field measurement includes test for dissolved oxygen (DO), pH and temperature by using DO meter, whilst laboratory experiments involve tests for biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS), total solid (TS), volatile suspended solids (VSS), oil and grease, and ammonia nitrogen. The tests used APHA, (2005), standard methods for the examination of water and wastewater[12].

Results and Discussion

The physical of POME is thick brownish liquid which contains a mixture composed of water, oil, and suspended solids are significant relationship by the POME characteristics. The characteristics of POME obtained from this study are depicted in table- 4 which the average values for the tested parameters. The data was recorded by MPOB and considered as typical values for the comparison.

Biochemical oxygen demand (BOD_5): The standard five-day BOD_5 value is commonly used to determine the amount of organic pollution in water and wastewater. Determination of BOD_5 tests are involve measuring the oxygen demand of both the organic matter and organism in the POME. It is used to measure the approximate amount of oxygen that will be required by bacteria and other microorganisms while stabilizing the decomposable the organic matter present. In this study, the BOD_5 concentration of POME is 10,197mg/l, while from previous study the range was 21,500 - 28,500 mg/l as shown in Table- 3. Meanwhile the most common value is 25,000 mg/l are recorded by Ma and Ong, Ahmad et al. and MPOB[13,14,15]. In the current study, the observed BOD_5 values are considerably low values as compared to previous study. It is about half of previous BOD_5 results are recorded by Ma and Ong, Ahmad et al. and MPOB[13.14.15]. Low concentration of BOD_5 shows that the effluent has less organic matter. That's mean the microorganisms will consume less oxygen to decompose the organic matter in the effluent. This difference in BOD_5 values may be due to vary of different batches, day and factories, depending on the processing techniques and age or type of fruits and some researchers believed it is also may be due to vary the discharge limit of the factory, climate and condition of palm oil processing[21].

Chemical Oxygen Demand (COD): Chemical oxygen demand (COD) is used to measure the oxygen equivalent of the organic material in wastewater. That is can be oxidized chemically by using dichromate in an acid solution. It is a useful measure of water quality. Most cases applications of COD determined the amount of organic pollutants found in water[22]. The results are depicted in table- 4, it can be seen obviously the COD concentration in this study is 50,500 mg/l and in the range of previous study as depicted in table- 3. The COD from previous study, the concentration range was 44 300 - 70 900 mg/l. The COD value is showing the higher than BOD value. The value of the ultimate BOD would be as high as the COD, it is very rare. A higher figure is 70 900 mg/l and is recorded by Wu et al., and a lower figure is 44 300 mg/l and is recorded by Zinatizadeh et al.[16.17]. This difference in COD value may be due to as mentioned as above.

Table-4
Characteristics of palm oil mill effluent (POME) from Malpom palm oil mill

Parameter	Units	Concentration
Biochemical oxygen demand (BOD_5)	mg/l	10 197
Chemical Oxygen Demand (COD)	mg/l	50 500
Total solid (TS)	mg/l	31 533
Suspended solids (SS)	mg/l	4 007
Oil and Grease	mg/l	15 800
Total Nitrogen	mg/l	613
pH	mg/l	5.32
Temperature	-	54
Volatile Suspended solid (VSS)	^{o}C	3 657
Dissolve Oxygen (DO)	mg/l	0.47

Total solid (TS): Total solids represent of all solids in a water sample. They're includes the total suspended solids, total dissolved solids, and volatile suspended solids. The present value of 31,533 mg/l is in the range of previous study are 33 7900 and 45 000 mg/l by Wood, et al., Wong, et al., and MPOB, respectively[15,19,20].

Suspended solids (SS): There are amount of filterable solids in a water sample. Samples are filtered through a glass fiber filter. The filters are dried and weighed to determine the amount of total suspended solids in mg/l of sample. The present value of suspended solids is 4,007 mg/l, about a quarter from the element recorded by Ahmad et al. and MPOB are 18 000 mg/l respectively[14.15]. The higher suspended solid is 25 800 mg/l and it is recorded by Wu, et al. [17].

Volatile suspended solid (VSS): Volatile solids are which solids lost on ignition (heating to 550 degrees C.) They are useful in application for treatment plant operator because they give a rough approximation of the amount of organic matter

present in the solid fraction of wastewater, activated sludge and industrial wastes. The present value of volatile suspended solid is 3,657 mg/l, but recorded data by Wood, et al., Wong, et al. 2009 was 27 300 mg/l to 30 150 mg/l in table- 3[19,20].

Oil and Grease: Oil and grease are poor solubility in water. Thus, oil and grease content of industrial wastes are important consideration in handling and treatment of the material for disposal. In this study, the value of oil and grease concentration is 15,800 mg/l, which is a very high of concentration to be compared with previous study, the ranges was 1 077 mg/l to 8 020 mg/. Oil and grease are recorded by Ahmad et al. and MPOB were 4 000 mg/l respectively[14.15].

Total nitrogen: Total nitrogen which is recorded by Wood, et al., and Wong, et al. was in the range of 500 mg/l to 800 mg/l[19.20]. While in this study was tested of ammonia nitrogen and the value is 613 mg/l. Total Nitrogen or TKN is the sum of organic nitrogen, ammonia (NH_3), and ammonium (NH_4^+) in the chemical analysis of soil, water, or wastewater. Nitrogen is an essential ingredient for cell growth but too much nitrogen freely available in the environment can be a bad thing. Excess nitrogen discharged into waterways can contributes to become rich in dissolved nutrients. It can also contribute to massive algae blooms leading to oxygen depletion in water and its associated problems.

pH: pH is a measure of the acidic or alkaline nature of a liquid that means the concentration of the hydrogen ion [H+] activity in a liquid. The pH of the acid wastewater is raised to the environmentally acceptable level. A pH range of 6.0 to 9.0 appears to provide protection for the life of freshwater fish and bottom dwelling invertebrates. The present value of pH is acidic, 5.32 while from previous study the concentration range was 3.4 to 4.7. While the most acidic POME was 3.4 to 3.6 which was recorded by Vijayaraghavan, K., et al.[18].

Temperature: Temperature is an essential water quality and environmental parameter because it influences the kinds and types of aquatic life, regulates the maximum dissolved oxygen concentration of the water. The organisms within the ecosystem have preferred temperature regimes that change as a function of season, organism age or life stage, and other environmental factors. In term of chemical and biological reactions, the higher the water temperature the higher the rate of chemical and metabolic reactions. The present study of temperature is 54^{o}C while the previous study was 80-90 ^{o}C[13].

Dissolve Oxygen (DO): Dissolve oxygen refers to oxygen gas that is dissolved in natural and waste water depends on the physical, chemical and biological activities in the water body. In present study of DO value is 0.47 mg/l. There is nothing recorded DO data from previous researchers as shown in Table-3. Analysis for DO is a key test in water pollution. DO levels in wastewaters depend on the physical, chemical and biochemical activities in wastewaters. Adequate DO is necessary for good quality of water. Oxygen is an essential element to all forms of life. As DO levels in water drop below 5.0 mg/l, aquatic life is put under stress, the lower concentration the greater the stress. Death usually occurs at concentrations less than 2 mg/l. The WHO (World Health Organization) suggested the standard of DO is > 5.0 mg/L for river water monitoring[23].

Conclusion

After a research was carried out with patience and perseverance, it finally indicated a little bit results and responding variables. It may a concise and precise conclusion, yet including in a vexed-question especially to know more about POME. POME consists of water soluble components of palm fruits and a thick brownish colloidal mixture of water, like palm fiber and oil. Despite of its biodegradability, within a pH value is acidic around 5.0 and it is harmful to the environment yet living things, POME cannot be discharged without first being treated. POME is a vital element in investigating the characteristics is needed to give a solution about its properties and important in choosing the suitable POME effluent treatment methods and monitoring the treatment plants. Effluent treatment methods will influence the cost of palm oil mill operation and maintenance, availability of industrial land, and the palm oil mill location. According to the previous research, the characteristics may vary of different batches, day and factories, depending on the processing techniques and age or type of fruit. The discharge limit of the factory, climate and condition of palm oil processing affects the characteristics of POME. Even though POME is arduous to be acquired as scarce as feathers on a fish in aquatic life, but within a current treatment methods, imply state-of-the-art techniques and sustainable practices in the disposal of the effluents. POME is treated under the thumb of a ponding system which consists of a series of ponds with different functions. This ponding system is applied more than 85% in whole countries in Malaysia.

However, all in all, further study is needed to take a longer duration, vary dilution of sample, and more batches of sample to establish the accuracy and precision. The laboratory tests are carried out to be as precise technique, accurate, specific and sensitive as possible, stringent the standard methods. Each test has its own performance measurement and appropriate application.

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