Analysis of POME Discharge Quality from Different Mill in Perak, Malaysia: A case study

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Abstract. Palm oil mill effluent (POME) is a major concern of oil palm mill because it contributes to numerous pollution such as soil, water and air pollution. In order to maintain a clean environment for a sustainable agricultural system in oil palm plantation, the quality of POME and its level must be monitored to ensure that the requirement set by the country is met. Hence, this paper is written based on the data of POME final discharge into waterways taken from Malaysian Department of Environment in four regions of Perak, Malaysia. The data is compared between regions and relatively different levels of discharge have been produced. Some of the mills produce final POME wastewater above the limit that has been set. The remaining mills discharge the wastewater below the maximum allowed level. This is an indicator that each mill has its own Standard of Procedures in treating POME before being discharged into waterways. It is suggested that the mills take a proactive approach to treat POME beyond the ponding system. POME can be physically processed to produce biofertilizer and biocompost for organic farming. The mills apply phytoremediation techniques in treating POME to reduce the unwanted variables that can affect the sustainability of our environment.

1. Introduction
Agricultural sustainability is a concept that refers to natural process integration, minimal use of non-renewable inputs that affected the environment and wellbeing of human through the utilization of skills and knowledge of the farmers who jointly solve agricultural problems [1]. In palm oil plantation especially in Malaysia, sustainable palm oil can be achieved by following the standard of Roundtable Sustainable Palm Oil (RSPO) and Malaysia Sustainable Palm Oil (MSPO).

There are two types of waste that produced by palm oil mill which in the form of liquid and solid. Solid waste mostly obtained from fruit bunches after being stripped and leaving the empty fruit bunches (EFB) while the liquid part is come from the whole extraction process at the mill [2]. The liquid discharge is known as palm oil mill effluent (POME), is one of the greatest issues in palm oil plantation due to its potential contribution to environmental pollution where untreated POME gives higher impact to environment compared to the treated POME. Every one ton of processing fresh fruit bunch (FFB) will produce 0.65 ton of POME [3].

The main three processes involved in producing POME are sterilization that produces 36% of POME, nut cracker separation using hydro cyclone (4%) and clarification (60%) [4]. The sterilization is taking place to “cook” the fresh fruit bunch under high pressure to loosen the fruitlets using a lot of water. This water will then be discharged into sludge pond. The nut cracker includes the usage of
hydro cyclone or clay bath method to separate and sort particle like oil and kernel. The clarification process is the final process to remove all impurities from crude oil in settling tanks.

POME also has high nutrients such as nitrogen, phosphorous, sodium, magnesium and calcium that may be utilized for crops and medium for microalgae growth even though it has been treated by using facultative anaerobic [5]. As stated by [6], POME is made up of 0.6-7.0% palm oil, 95-96% water, 4-5% total solid, and 2-4% suspended solid. As stated by [2], the main components that produce the POME which high in chemical oxygen demand (COD) and biological oxygen demand (BOD) values are the high amount of wastewater and oil grease from the CPO process. Because of the extremely high content of organic pollutants, POME requires numerous treatment stages. This is to prevent problems in the biological method stages and follow with water-discharge requirements.

| No | Parameter          | Concentration (mg/L) | Average (mg/L) |
|----|--------------------|----------------------|----------------|
| 1  | pH                 | 4.15-4.45            | 4.25           |
| 2  | COD                | 1350-2120            | 1600           |
| 3  | Soluble COD        | 20500-24500          | 22000          |
| 4  | BOD                | 300-400              | 330            |
| 5  | Total volatile solid | 27300-30150        | 28100          |
| 6  | Total suspended solid | 15660-23560        | 18900          |
| 7  | Total phosphorus   | 200-600              | 350            |
| 8  | Total nitrogen     | 500-800              | 500            |

*All parameters are in unit of mg/L except pH*

In Malaysia, Department of Environment has imposed a regulation regarding the effluent discharge from the oil palm industry. Since Malaysia is moving forward to make sustainability for mill is compulsory under MSPO, hence the treatment of POME before discharging into waterways is crucial. Hence, this paper is presents the quality of treated POME discharge and the treatments that have been applied in the oil palm industry recently.

2. Materials and methods
The study was conducted in Perak, Malaysia since this state has the largest area of oil palm plantation area in the northern region of Malaysia. The data was collected by referring to the Department of the Environment (DOE), Perak. Generally, palm oil mills will submit their report on POME quality to the Department of the Environment quarterly.

In this case study, the data used was secondary data on POME qualities of four mills obtained from the Malaysian Department of Environment of (DOE) Perak. The raw data was intended to serve as comparison for compliance study. Secondary data is basically the data or information that was either gathered by someone else for some other purposes [8].

The parameters of this case study are biochemical oxygen demand (BOD), oil and grease, suspended solids, ammonical nitrogen, total nitrogen, temperature and pH. All of the parameters are then used to compare to the management practices of POME by the palm oil mill. The management practices include the number of pond for palm oil mill effluent, the applications of treated palm oil mill effluent and the availability of bacteria for solid degradation purposes.

2.1 POME qualities
There are many important POME qualities of palm oil mill effluent, as listed in the parameters set by DOE. The parameters are set so that the POME that will be discharged into the watercourse will not cause any pollution. There are seven most important parameters for POME qualities and the parameters are biochemical oxygen demand (BOD), oil and grease, suspended solids, ammonical nitrogen, total nitrogen, temperature and pH. The parameter limits are listed in Table 2.
Table 2: Parameter limits for POME before discharged into waterways [9]

| Parameter                          | Units     | Parameter limits for POME discharge |
|------------------------------------|-----------|-------------------------------------|
| Biochemical oxygen demand (BOD, 3-day, 30 °C) | mg/litre  | 100                                 |
| Oil and grease                     | mg/litre  | 50                                  |
| Suspended solids                   | mg/litre  | 400                                 |
| Ammonical nitrogen                 | mg/litre  | 150                                 |
| Total nitrogen                     | mg/litre  | 200                                 |
| Temperature                        | °C        | 45                                  |
| pH                                 | -         | 5 – 9                               |

Under Principle 5, a mill must have a waste administration plan to avoid or lessen the pollution by observing the source of pollution and converting them into value added products. Subsequently, the mill must have Standard of Procedure to guarantee legitimate and safe handling technique and consent to Environmental Quality Act 1974.

3. Result and discussion

There are seven parameters of POME that should be recorded which are the reading of BOD, oil and grease, suspended solid, ammonical nitrogen, total nitrogen, temperature and pH. Unfortunately, among the four mills, two of them did not submit the reading for all parameters. This is due to the negligence of palm oil mill managers since it does not give any significant for them to know. Table 3 below shows the average reading for the seven parameters that have been listed by DOE.

Table 3: The Average Reading of Seven Listed Parameters Taken from Four Palm Oil Mills Water Discharge

| Palm oil mill | Average BOD (mg/l) | Average Oil and Grease (mg/l) | Average Suspended Solid (mg/l) | Average Ammonical Nitrogen (mg/l) | Average Total Nitrogen (mg/l) | Average Temperature (°C) | Average pH |
|---------------|--------------------|-------------------------------|--------------------------------|----------------------------------|-----------------------------|--------------------------|-----------|
| Kerian Region I Perak Tengah Region I | 62                 | na                            | 126                            | 63                              | 89                          | 30                       | 8.3       |
| Batang Region I | 75                 | 2                             | 92                             | 44                              | 143                         | 30                       | 8.4       |
| Hilir Perak Region I | 48                 | 7                             | 233                            | 21                              | 38                          | 27                       | 8.6       |

Only Perak Tengah Region I and Batang Padang Region I have submitted the full readings. Kerian Region 1 has not submitted oil and grease reading while Hilir Perak Region 1 has not submitted its BOD reading.

By analyzing the data, it can be seen almost all palm oil mills comply to each parameter except for Hilir Perak Region I, where pH reading of the mill exceeded the acceptable range.

For BOD, there are three different parameters required by DOE. The parameters were divided into two main categories, which are for water that will be discharged into the river and for land application, which is for fertilizer purposes. For the ones that will be discharged into the river, the lower the BOD,
the better the quality. In this paper, only BOD for water discharge is considered. The BOD reading was taken from below water catchment.

Meanwhile, for oil and grease, the parameter set by DOE is 50mg/l and the parameter is set only for effluent that will be discharged into the watercourse. From the data collected, only Kerian Region I did not submit the reading while the others had reading below the set parameter. This parameter is important because high amount of oil and grease will block the sunlight penetration to the bottom of the river. This will lead to difficulty in degrading the effluent.

As for ammonical nitrogen, the parameter set is 150mg/l. The result shows that all palm oil mills did not exceed the limit of ammonical nitrogen. Excessive amount of ammonical nitrogen will give direct impact to aquatic lives since it will increase the respiratory level and oxygen uptake by aquatic lives. The parameter set for total nitrogen is 200mg/l. Generally the amount for total nitrogen is higher than the parameters set for ammonical nitrogen as the total nitrogen contains more elements other than ammonical nitrogen.

The temperature required by DOE for effluent that will be discharged is 45°C. All of the palm oil mills that submitted their reading for temperature show that the temperature of the treated effluent discharged follows the parameter set by DOE. High temperature reduces the oxygen holding capacity thus supplying insufficient amount of oxygen to the aquatic life. The acceptable range of pH set by DOE is 5 – 9. Only Hilir Perak Region I of palm oil mills exceeds the maximum allowable pH but with a slightly high amount.

3.1 POME Treatment Method

All the palm oil mill in this study have utilized the ponding system because it is low in cost and easy to maintain since it located near to the mills. This ponding system demands long reservation period and also requires large areas for implementation. Generally, the ponds for effluent will start with cooling pond, mixing pond, anaerobic pond, aerobic pond and facultative or stabilization pond. The number of ponds may vary as the palm oil mills may have different amount of cooling ponds, anaerobic ponds and aerobic ponds. There are some palm oil mills that have only one cooling pond while other palm oil mills have two cooling ponds. The cooling pond is the pond that contains raw POME from mills, which are produced from the process of CPO productions.

POME in the pond will undergo biological degradation where this method is effective and has high efficiency in getting rid of the suspended solids, organic matter and oil and grease. This is because it has high organic loading capability and requires low energy. POME microorganisms have discovered application in POME bioconversion into functional and demanding products. However, the trend varies between palm oil mills. The variation between the data may be due to the inefficiency of bacteria for degradation process.

Other than discharging the treated POME into watercourse, POME can undergo physical treatment to produce biofertilizer and biocompost. This is because after treating raw POME, it will produce suspended solids or sludge and disintegrates solid. Both of them have high nutrient value compared to slurry and produce fetid scent. The sludge is then can be dried up and utilized as biofertilizer, biocompost and manure after undergoing specific treatment. DOE has set an allowed BOD level for treated wastewater discharge into watercourse at only 100mg/l while the BOD level for fertilizer applications to as high as 5000mg/l. By referring to the main objective of the application, palm oil mill managers shall know the best practices that they should apply in order to comply with the required parameter.

Also, the usage of aquatic or semi-aquatic plants such as *Chlamydomonas incerta* which is also known as the microalgae and apu-apu or *Pistia stratiotes*, a small plant with wide leaves is still reassuring as the wide leaves cover larger absorption area of waste in the wastewater treatment by removing unwanted nutrient and also chemical oxygen demand (COD) and BOD. They also readily remediate toxic pollutants in freshwater and seawater. This method is called phytoremediation. It is a remediation method that use green plants to reduce the contaminants without the need to excavate the contaminant elsewhere and can be done in-situ. This method is very effective and inexpensive.
However, it will take a long time to fully remediate pollutants and only selected plants are suitable. It also only can be applied at the final discharge of treated POME effluent.

4. Conclusion
As can be seen, POME quality is differed from one mill to another and this is due to the management practice. Hence, in order to conform to DOE’s parameter of POME quality, the best management practice should be applied by palm oil mill. The managements have to ensure the availability and the efficiency of microorganisms in the effluent pond by measuring the rate of degradation (mg/L). This is because the rate of degradation can be hastened through the addition of microorganisms in the pond, as suitable microorganism addition is efficient in degrading the compost.

As for the physical method, composting is still the most effective and economical in POME treatment. This is because composting can control the nutrients and acts as bulking agents that can be considered as an alternative option in improving the oil sludge bioremediation. The palm oil mill management should also consider treating POME and recycling the sludge to come out with value-added products, which can be reused in plantation. This will help the management to overcome the problems brought by while reducing a lot of cost.

It is also relevant to implement this biological method such as phytoremediation as it is cost-effective and do not need extensive equipment and labour. As a whole, best management practices should be applied by all palm oil mills in Malaysia. This includes the constant frequency of POME quality determination; obtaining the best qualities relevant to the application of treated POME. As a conclusion, the oil palm mill management team must be fully responsible in ensuring the conservation of environment from being damaged by the oil palm waste.

Acknowledgments
Authors wishing to acknowledge assistance and encouragement from colleagues, Department of Environmental of Perak State and financial support from Universiti Teknologi MARA.

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