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Pollution Reduction Technology in Palm Oil Mill through Effluent Treatment and Management

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Abstract – *In achieving the status as one of the largest exporter of palm oil products, Malaysia's palm oil mills have endlessly try to manage wastes coming from palm oil extraction processes. The main concern is to reduce the effluent that endangers aqua marines, while trying to be environmentally friendly industry in Malaysia. Most common method adopted by palm oil mills in this country is the ponding treatment, where stages of pond retain palm oil mill effluent (POME) and treat the viscous liquid waste through anaerobic treatment process. In recent years, many technologies have been looked into by researchers in making effluent treatment much more efficient, and also to perhaps utilize effluent to produce energy. Some of them include methane capture during anaerobic treatment, and also producing feedstock.*

Keywords: palm oil, palm oil mill effluent, sludge palm oil, effluent treatment, green technology

1.0 INTRODUCTION

Malaysia, being one of the largest exporter of palm oil with 44% of world's palm oil exports, currently cultivates palm oil from more than 5 million hectares of plantation area all around the country in the year 2013.

With about 429 mills operating across Malaysia, producing a total of 19.22 million tons of crude palm oil (CPO) in the same year [1], the amount of palm oil mill wastes abundant in palm oil mills increases each year.

The wastes in palm oil mill come in two types, liquid and solid forms. Solid wastes mostly derived from fruit bunches after being stripped leaving empty fruit bunches (EFB), and also kernel shells that is left behind after kernel is recovered for another round of extraction. Liquid waste on the other hand, is the leftover from the whole extraction process throughout the mill.

To make it simple, the method of extracting CPO from fresh fruit bunches (FFB) needs high amount of water that is used through various stages of processes. The water is needed in the form of steam for sterilization of FFB and also dilution of CPO. In general, for every tonne of FFB processed, about 1 tonne of water is used for the extraction process each time.

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The high amount of water results in the discharge of large amount of liquid into sludge pit and cooling pond, the waste water is widely known as the palm oil mill effluent (POME). Besides liquid being discharged, small amount of leaked oil from various stages of milling are also included in POME. To make matters worse, there are oil losses detected in almost every major process along the line.

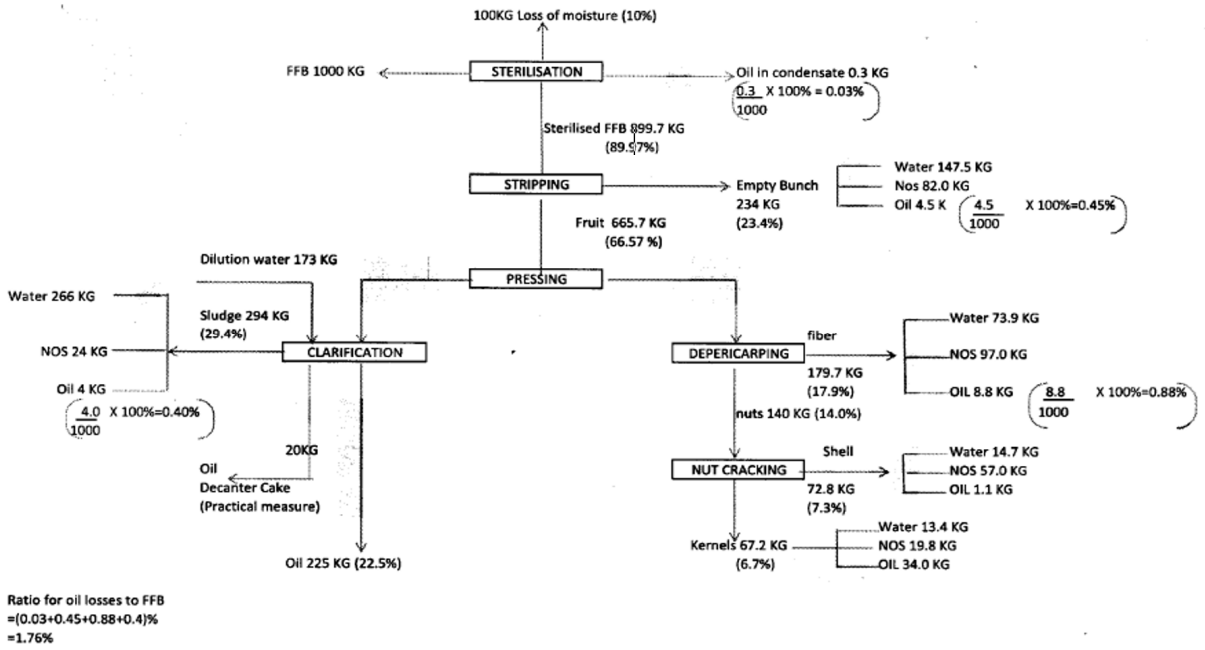

Figure 1: Typical Mass Balance in Palm Oil Mill

This leached oil ended in the same pond, creating a thick surface on top of the liquids in the pond and traditionally recovered by pump contractor. The oil being recovered from either cooling pond or sludge pit is called sludge palm oil (SPO). It is widely predicted that Malaysia's palm oil industries generate about 50,000 tonnes of SPO every year. Shown in Figure 1 is a typical mass balance in a palm oil mill, indicating much oil leakage throughout the process.

The wastewater that is left behind after trapped oil removal still contains heavy amounts of chemical oxygen demand (COD) and bio-chemical oxygen demand (BOD). Both COD and BOD affects marine lives in a negative way, polluting water bodies.

2.0 PALM OIL MILL EFFLUENT

As discussed, the high amount of waste water and oil coming out from the CPO processes are the main components creating the POME that has high COD and BOD values. POME has distinctive characteristics, and there are strict regulations set by Malaysia's Department of Environment (DOE) for the release of treated wastewater into the environment. It is not surprising then, with

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the high number of production capacity of palm oil Malaysia is having, palm oil industry is claimed to be the generator of the largest pollution in rivers throughout the country [3]. In 2008 alone, more than 44 million tons of POME is generated by the industry [4].

2.1. POME Characteristics

POME has a thick brownish color, and is usually in the form of a viscous slur when fresh out of the mill. Being acidic in nature, POME's high BOD value physically means its soaring content of organic matters [2]. As no chemical is added during oil extraction process, POME is not toxic yet it is way more polluting than domestic sewage due to the high content of suspended solids and oil. These contents give the resulting high BOD and COD values to the effluent in palm oil mills.

2.2. Harmful to the Environment

POME is mainly harmful due to the BOD and COD elevated values, which is due its contents of sellulose mixed with residue oil (forming suspended solids and thick layers of oil). These values indicate the activity in the effluent, and how it will affect water bodies it shall be in contact with. BOD shows the amount of biological activity in the wastewater, in which higher BOD means higher oxygen needed by the wastewater. COD on the other hand provides the amount of organic compounds in the wastewater, also showing the amount of oxygen needed by the wastewater. If such wastewater with high BOD and COD reaches water bodies, for example a river, oxygen will slowly be non-available for the aquatic lives in the river. Not only is the polluted water body harmful to the aquamarines, but it will also be unsafe for human consumption thus depleting local water supply.

3.0 POME TREATMENT METHOD

Previous survey made by Ma et. al. [5] as mentioned in the paper published by PORIM [2], stated that there are five different treatment processes and systems that is used by Malaysia's palm oil industry. Yet, the most popular and cost efficient for the trade is the ponding system which consists of a number of ponds with their own purposes.

3.1. Ponding System

It is estimated that more than 85% of the palm oil mills in Malaysia utilizes this treatment system [5]. The reason is mainly due to the cheap cost to construct the ponds, and easy maintenance it afforded the mills. Yet, the system of multiple ponds requires a lot of land (large area) [2]. Normally it is 5 meters to 7 meters deep for the anaerobic pond, while the facultative pond is 1.5 meters deep. This is only considering a simple two-phase operation as shown in Figure 2 where acidification phase is alienated from the methanogenic phase [2].

Ponding system requires long retention times though, and as mentioned large areas application. Also, due to the sludge build up in the anaerobic pond, there are cases where the treated wastewater could not meet the discharge standard of 50mg/l BOD [6]. A summary of parameter limits for the

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discharge of POME into water bodies in Malaysia has been discussed in a previous review paper written by Ta Yeong Wu et.al. [4] and is provided in Table 1 below.

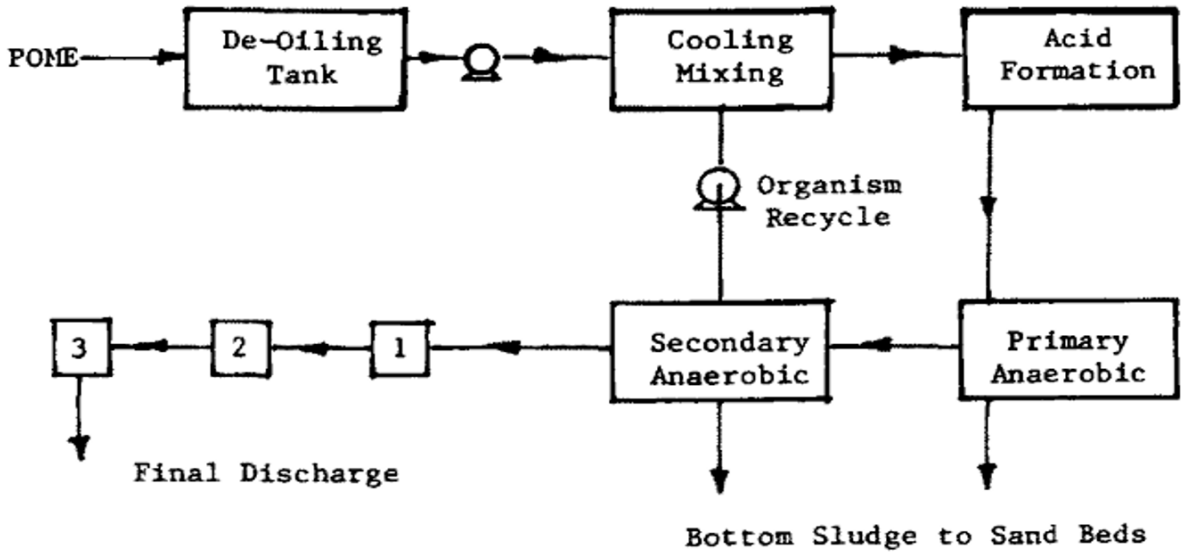

Figure 2: Simple Ponding System for POME Treatment [2]

Table 1: Parameter Limits for POME Discharge into water bodies in Malaysia [7]

Parameters[a]	Limits according to periods of discharge					
	1-7-1978–30-6-1979	1-7-1979–30-6-1980	1-7-1980–30-6-1981	1-7-1981–30-6-1982	1-7-1982–31-12-1983	1-1-1984 and thereafter
BOD_3[b]	5000	2000	1000	500	250	100
COD	10,000	4000	2000	1000	–	–
Total solids	4000	2500	2000	1500	–	–
Suspended solids	1200	800	600	400	400	400
Oil and grease	150	100	75	50	50	50
Ammoniacal nitrogen	25	15	15	10	150[c]	150[c]
Total nitrogen	200	100	75	50	300[c]	200[c]
pH	5.0–9.0	5.0–9.0	5.0–9.0	5.0–9.0	5.0–9.0	5.0–9.0
Temperature	45	45	45	45	45	45

[a] All parameters are in units of mg/l with the exception of pH and temperature (°C).
[b] The sample for BOD analysis is incubated at 30 °C for 3 days.
[c] Value of filtered sample.

4.0 SLUDGE ELIMINATION FROM THE PONDS

Previously discussed is the problem anaerobic treatment method faces in the ponding system, where sludge builds up and prevents the ability of mills to be in accordance to strict regulations of BOD value of the wastewater they emit to water bodies.

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4.1 Sludge Palm Oil

Sludge in the waste water contains suspended solids, which are as mentioned by Ma [2], residual oil mixed with sellulose. The sludge oil, or usually referred to as sludge palm oil (SPO) ranges with different free fatty acid (FFA) content, from 2% up to more than 80%. Besides that, SPO also is made up of impurities such as aldehydes, ketones, alkanes, furan and phenol [8]. This usually makes anaerobic digestion quite impossible, and thus making the resulting downstream wastewater having high BOD still.

4.2 Common Practice of Palm Oil Mills

In current palm oil mills, they practice a simple way of extracting SPO out of the ponds via a submersible slurry pump [2] as shown in Figure 3. This process of desludging is done regularly during retention of POME in the acidification and anaerobic ponds.

Figure 3: Pump Extracting SPO from Pond

The recovered oil is usually sold off, and currently it is the cheapest palm oil in the market, with quite no distinct uses. Researches has been done in converting the oil into bio-fuels, to fire up burners in the palm oil mills. Besides that, methane capture during anaerobic and aerobic digestion ponds are also being studied and applied in a few mills in Malaysia.

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4.3 Sludge Palm Oil as Burner Fuel

Besides SPO are being researched as bio-fuels, the industry is still mainly selling SPO for lower grade product manufacturers, while also using dried SPO for bio-mass burners. Bio-mass burners contribute to palm oil mills large emission of PM and carbon, which does not help in the palm oil mills effort in meeting the DOE's strict regulation on emission.

A research to explore the idea of using SPO as a fuel to be used directly in burners might be something that could prove beneficial in the long run for the industry. However, the highly viscous liquid oil with high FFA content restricts the mills from ever using it as liquid fuel for burners. Therefore, a research into a new nozzle design that could utilize SPO for burners might be something that could help the industry in this regard.

4.4 Water-Mixing Burner for SPO

As highlighted by Kuntum[8], SPO has the quality nowhere near CPO or any oil derivation of palm oil FFB. In fact, the quality is inferior due to the wide range of free fatty acid (FFA) value it has, from 2.21% up to 88.34% with many factors able to affect the value itself. For example, FFA content differs according to the time the sample is taken as well as the point it was taken from the pond system or the sludge pit. Other than FFA, SPO also contains impurities such as aldehydes, alkanes, furan, ketones, and phenol, alongside high moisture content.

Now this contributes to another reason why SPO might not be suitable to be burned directly as the numerous content of impurities and solids will make the emissions quite as bad as a bio-mass burner. However, a recent experiment conducted by Kidoguchi et.al. [9] has explored the idea of introducing water into burner combustion field and the results show that there are considerable reduction of PM and carbon emissions. The result is as showed in Figure 4.

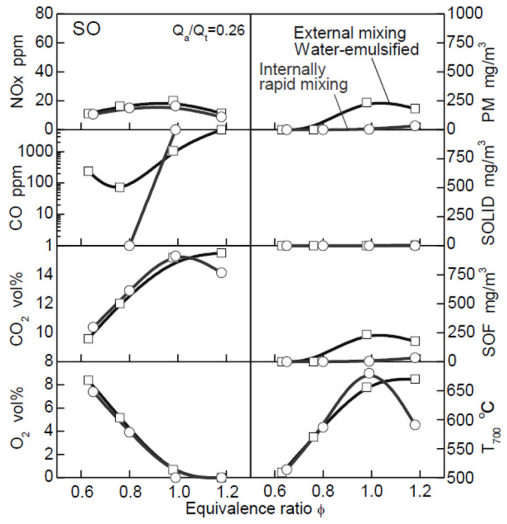

Figure 4: Comparison of Emissions Between Two Types of Injector (Fuel: soybean with water mixing or emulsified with 50% water) [9]

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The results are observed when water is introduced through internally rapid mixing nozzle designed by them, as shown in Figure 5.

This shows a possible method in trying to introduce SPO as fuel for industrial burner in palm oil mills, but a thorough study on SPO characteristics and the proper nozzle to be designed should be conducted.

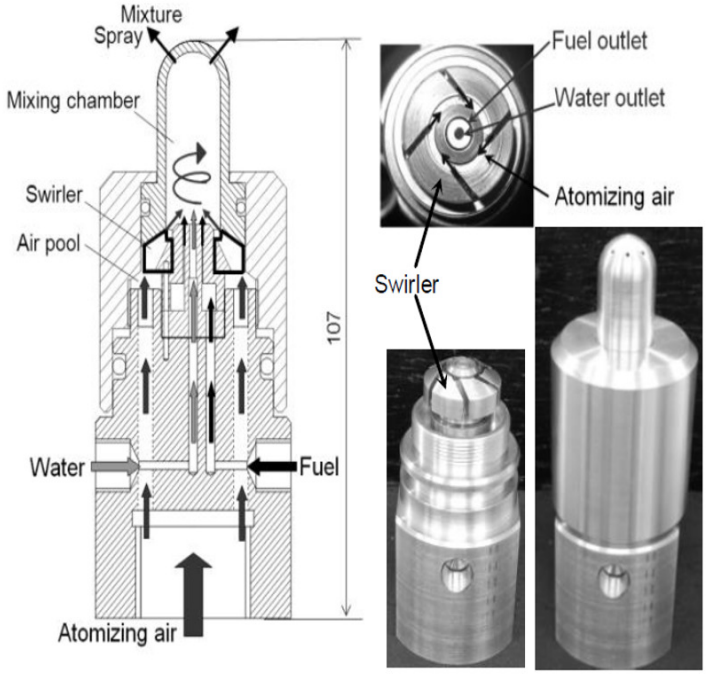

Figure 5: Internally Rapid Mixing Nozzle [9]

5.0 CONCLUSION

In a nutshell, POME containing SPO is currently one of the main concern of the palm oil industry in Malaysia. Researches are being conducted continuously to solve the problem of polluting value of POME. The main focus currently is to use the extracted sludge oil, to give it perceivable value in the market as fuels. A much interesting research to be taken into consideration would be in using SPO as fuel for burners, eliminating the worry of high capital cost, at the same time bringing added value to the sludge oil.
One of the possible method to use SPO as fuel is perhaps to introduce a water mixing burner system that could potentially reduce the harmful emission of SPO. By reducing SPO from the treatment ponds, wastewater could further meet the DOE standards, being less harmful to the environment.

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