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Processing technology POME-pond in Indonesia: A mini review

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Abstract. The purpose of this paper is to discuss the process of POME-Pond technology in Indonesia and its utilization for sustainable waste management. Indonesia is the largest producer and exporter of palm oil. Liquid waste in the form of POME produced is a waste that is highly polluting the environment and can be a major problem for the surrounding environment if not treated properly before disposal in accordance with standard waste quality standards. Driven by the need to find renewable energy sources, many technologies are being developed to process POME into biofuels. To further develop this technology, it is important to understand the stage of development of POME processing technology and the challenges that must be handled currently.

1. Introduction

The palm oil industry produces large amounts of residues that can be processed to produce biofuels. As stated earlier, in oil palm plantations, the extracted oil only covers 10% of the total biomass produced while the other 90% is considered as waste. With the rapid growth of the palm oil industry, more residue will be generated, adding to the complexity of current waste management procedures. On average, 50 to 70 tons of biomass residues are produced from every hectare of oil palm plantations [1].

The by-products or wastes generated from palm oil production includes oil palm trunk (OPT), oil palm frond (OPF), empty fruit bunch (EFB), mesocarp fruit fibre (MF), palm kernel shells (PKS), and palm oil mill effluent (POME). Except POME, these wastes have high fibre content [2]. The only liquid waste produced from the palm mill is POME, as shown in Fig. 1 POME has the largest volume of waste from processing palm oil mills. It mainly consists of water with small amounts of solid and oil. The processes that generate huge amounts of POME in palm oil processing plants include sterilization, crude oil clarification, and cracked mixture separation [3].



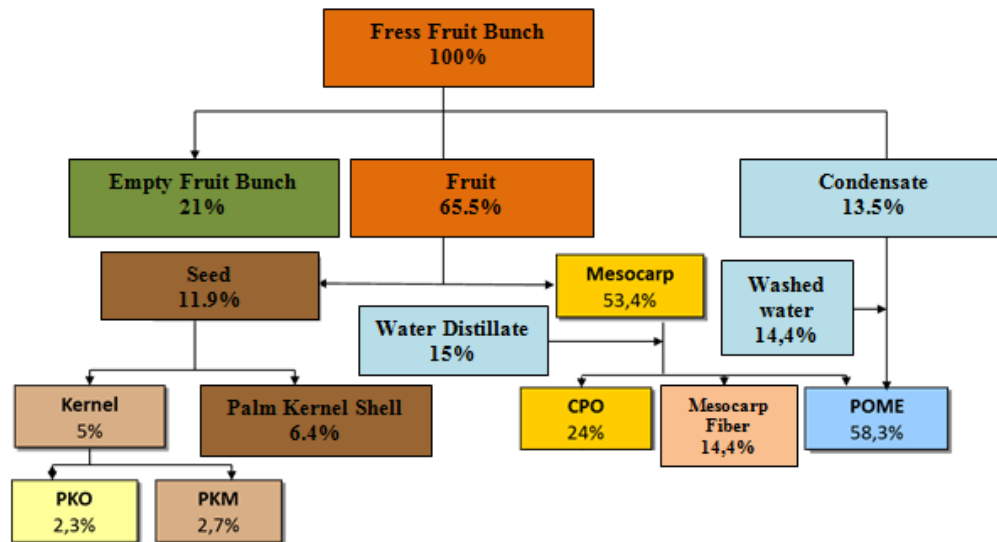


Figure 1. Mass balance of palm oil processing [4]

In fact, this huge amount of POME is the result of the tremendous amount of water used to clean up the palm fruit and to extract the oil from the mesocarps. To extract 1 ton of crude palm oil, approximately 5-7.5 tons of water is used, out of which more than half (i.e., >2.5-3.75 tons) ends up as POME [5]. Even though it is considered as non-toxic material, POME cannot be discharged to the environment directly without treatment as it is acidic and contains residual oil which cannot be easily separated using the gravitational method [6].

Some of the research said that the most widely used POME waste treatment in Indonesia today is using the ponding system. Processing with this system through anaerobic and aerobic decomposition processes. Disadvantages of this system in addition to requiring a large area and a long retention time, also can release harmful gases such as methane gas and causes the accumulation of mud [7]. As we known that POME characteristic from pond to pond does not fulfill the Ministry of Environment and Forestry's regulation about waste water quality standard. In line with that, the first pond has the highest oil composition and proved that the extract oil can be processed directly into biofuels [8].

To achieve that, an overview on the POME like regulatory, processing technology (ponding system), potency of POME and current utilization scenarios including their techno-economical aspects is presented and discussed. So, the purpose of this research is find out whether ponding systems are still feasible to be forwarded or replaced with other systems that can produce sustainable energy such as biofuels.

2. POME and Its Regulatory

Based on decision of Minister of Environmental and Forestry No. 28/2003 state that utilization of wastewater from the palm oil industry on land in oil palm plantations must meet the environmental impact analysis (AMDAL) study, environmental anagement efforts (UKL) and environmental monitoring efforts (UPL). And to find out whether or not there is pollution, validation can be carried out which refers to the quality standard of waste water according to Ministry of Environment and Forestry's regulation No. 5/2014 [9].

POME contains high concentrations of organic compounds such as protein, carbohydrate, nitrogenous compounds, lipids, and minerals, making it suitable as plant fertilizer provided that it is properly treated [10].

POME is the biggest waste generate from palm oil mill. Currently, POME was treated mainly through anaerobic digestion in series of open anaerobic ponds followed by land application of treated POME. Huge amount of POME with high concentration of organic content implicates a high potential to cause environmental pollutions if it is not properly treated. In contrary, the utilization of POME can produce some valuable materials or energy which is important to support the sustainability of palm oil plantation and palm oil mills [11].

3. Potency and Prospect of POME

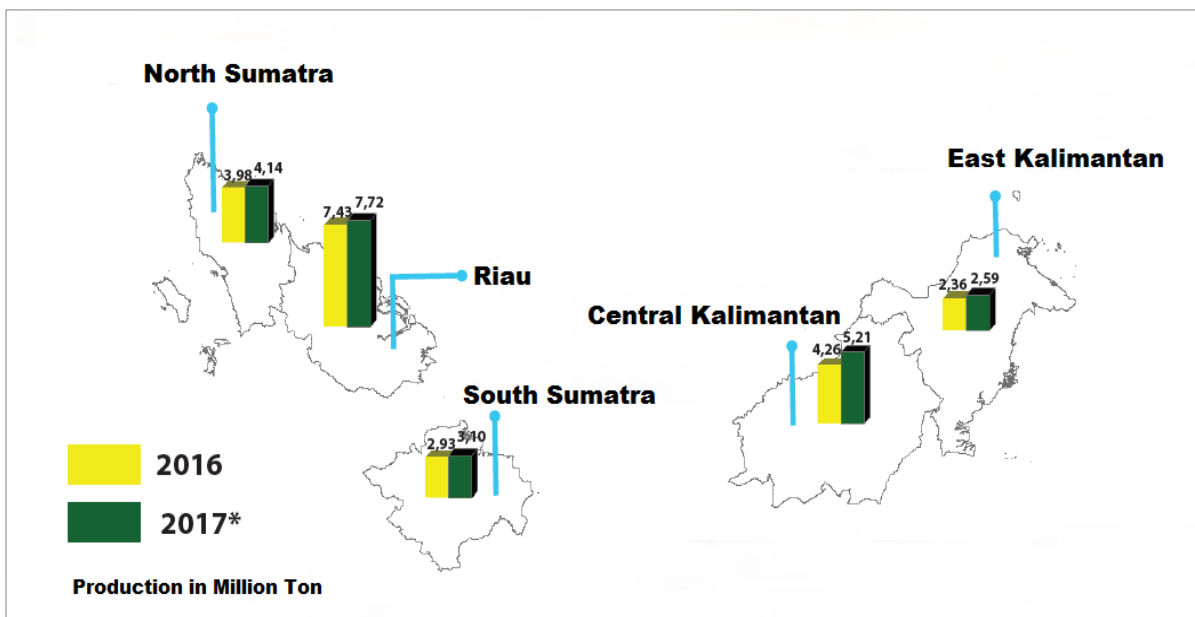


Figure 2. The Five Largest Provinces of Palm Oil Producers in Indonesia [12]

This growing palm oil industry has changed the economy scenario especially in Indonesia as palm oil is one of the main export commodities. In fact, the palm oil industry has been a source of income and employment for the indigenous communities residing near the plantations and has led to substantial improvements in their life quality. The industry has also provided access to healthcare and education for the indigenous communities. A study revealed that millions of people currently working in the oil palm industry, used to live in poverty. In addition to that, the industry continues to generate huge revenues for the producing countries. Therefore, it is not surprising that the oil palm industry is expected to grow further in the coming years [13].

Similar to the distribution of oil palm plantations, national palm oil mills are distributed all over 22 provinces. Fig. 2 shown that Riau province has the most palm oil mills of 140 units with production capacity of 6660 tons FFB/hour followed by North Sumatra with 92 units and production capacity of 3815 tons FFB/hour and West Kalimantan with 65 units and production capacity of 5475 tons FFB/hour. In all, there are 608 units of national palm oil mills with production capacity of 34,280 tons FFB/hour. In 2030, it was estimated that there would be a production of 54 million tons EFB, 31 million tons MF, 15 million tons PKS, 130 million tons POME, 115 million tons oil palm frond, and 59.7 million tons oil palm trunk. Further research and technology development need to be done in order to improve the added value of oil palm waste biomass [14] especially for POME.

4. Processing Technology of POME

Generally, POME in Indonesia was treated biologically using a series open pond followed by land application or aerobic process. To achieve the land application requirements, liquid waste from palm oil mills is processed by biological processes through stages [15] :

- Cooling pond, is a pond for the process of cooling wastewater to reach a temperature that allows bacteria to be active in activities.
- Anaerobic pond, pond to reduce organic wastewater by bacteria under conditions without oxygen.
- Contact pond, a pond to collect liquid waste for quality inspection before being transferred to Land Application as liquid fertilizer.

Benefits of this system include simple and inexpensive, low investment and equipment costs and low energy requirements. While the disadvantages of this pond system are that it requires a very large area, it takes around 5 ha for palm oil mill which has a capacity of 30 tons FFB/hour, needs maintenance costs for disposal and handling of mud from ponds, eventually waste will also be discharged into rivers which can cause pollution environment, the emission of methane gas into free air can cause a greenhouse effect 20 times more than carbon dioxide gas.

At present the management of POME using only open ponds is starting to be considered less efficient and less environmentally friendly. The owner or palm oil mill management has begun to change by modifying existing ponds with other management technologies. There are a number of new POME processing technologies currently, among which the new technology is membranes and finally heard by electrocoagulation. The emergence or development of POME management technology is caused by several specific purposes and objectives. Some of the objectives are [16] :

- Get technology that is more environmentally friendly (environmental friendly). This technology is generally to avoid greenhouse gases, especially methane gas released into the atmosphere.
- Obtain a source of economic benefits. This technology is done by getting new products that can be sold using POME.
- Facilitate management operations, especially for workers in palm oil mill.
- Limited land in the palm oil mill area to use an open pond system (limited area).
- Process technology factors in palm oil mill. This factor is related to the modification of process technology in processing FFB in palm oil mill, or the presence of new process technology. Differences process was primarily associated with the use of a new process. Examples of this factor are changes in sterilization, clarification technology and so on. Changes in process tools have an impact on changes in the quality, quantity and type of waste produced in palm oil mill.
- Obtain a source of energy.

From the above objectives, there are currently several POME management technologies in addition to the open pool system. The technologies include [17] :

- Aerobic management using aerobic ponds. This technology is used to avoid the formation of methane gas. This technology is rarely used because it requires a large amount of energy to move the aerator.
- Drying technology (drying process), this technology is not suitable because it requires large costs and energy to evaporate water in POME.
- Land application, this system is not recommended because it requires substantial costs. Besides this technology still requires a pool without air and still produces methane gas.
- The use of oil palm empty bunches into compost, POME is used as a watering agent in the process of composting oil palm empty bunches as shown in Fig. 3. This technology is good to do. This technology requires a little high investment but benefits from the sale of compost.
- Use of POME to produce energy. Technology to produce energy is by capturing methane gas. The technology for capturing methane gas is a new one that builds a tank (biogas reactor)

which is above the surface as shown in Fig. 4 or by closing the existing waste pond using a cover with thick parachute material (covered lagoon).



Figure 3a [18] & 3b. Composting oil palm empty bunches



Figure 4a & 4b. Biogas Reactor & Covered Lagoon [19]

5. Current and Modern Utilization

The methane from POME, however, could be used far more efficiently through capture and use for power generation (POME-to-electricity). Less than 10 percent of around 640 palm oil mills in Indonesia treat their POME using biogas technology; the real potential goes untapped [20].

In addition to producing methane gas as energy, POME is also reported to be able to produce hydrogen gas (H_2) as energy. POME produces hydrogen using electrocoagulation technology that uses the principle of electrolysis, has two electrodes namely the cathode and the anode. These cathode electrodes form bubbles of hydrogen [21].

From several studies, the use of POME began to be directed towards biofuel. The oil content in POME can be extracted into the base material of biodiesel, because the oil comes from the imperfect pressing results of the fresh fruit bunch. This utilization can be directly integrated when the POME will be disposed of in the first pit (hot pit), oil that is still integrated with POME can be directly separated from other contents such as water and sludge [22].

6. Techno - Economic Aspects

The technology of processing palm oil waste is now diverse and has different objectives. There are technologies that require more investment, but will benefit from the sale of products or the results of the waste treatment technology. Each technology has strengths and weaknesses. Therefore, if we want to choose which technology to use it must be adjusted to the conditions of palm oil mill and also financial capabilities [23].

Despite the high potential for bioenergy mitigation activities, private developers are still hesitant to invest in POME-to-electricity. The main reason is the palm oil industry's unfamiliarity with technologies used in methane capture, and particularly in dealing with PT PLN - the state-owned electricity generator and supplier - in selling power. Consequently, they prefer to invest in new plantations - which can lead to more land use change. Successful models for biogas projects have no promotion and remain widely unfamiliar. Developers of power plants face financial obstacles, as well as technical and institutional challenges [24].

7. Research and Development Needed

The appropriate technology of POME treatment and utilization system for each palm oil mill depends on the condition of palm oil mill and plantation, energy supply and utilization, and how much the management pays attention on greenhouse gases (GHGs) emission reduction initiative. Evaluation of current condition of POME treatment and utilization systems in some palm oil industries is required to clarify the environmental impact and advantages of each system. From the evaluation, a sustainable POME treatment and utilization system can be developed [25].

As discussed above, utilization of POME is being intensively conducted research is into biofuel. So that some of the crude palm oil produced or off-grade recovered from POME can be processed and converted to biodiesel product. Biodiesel plant integrated to the palm oil mill was one of the strategies to produce biodiesel fuel with lower investment and production costs, and the biodiesel product could be used for substituting diesel fuel for internal use in the oil palm industry. Development of biodiesel plant with appropriate capacity will ensure the supply of biodiesel fuel for diesel fuel substitution in oil palm industry [26].

8. Conclusion

Currently, the use of pond technology is still continue and it should be slowly abandoned, in addition to requiring a very large area of land that can potentially damage the environment, because the waste released is eventually discharged into the river. The pilot project that has been running on the use of POME is to become biogas which can be used as electricity, but unfortunately this utilization requires a substantial investment.

The current hot topic is the use of POME as a biofuel feedstock. These studies still continue both in terms of technology and economic aspects and expected that this research can be realized immediately to become the first project in Indonesia, especially to fulfil biofuel.

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