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Cleaner Production Opportunity at Palm Oil Plant to Minimize the Wastewater Effluent and Solid Waste Generation

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Abstract. *PT MNA is a palm oil industry that has a processing capacity of 60 tons of FFB/hour with its main products of palm oil (CPO) and Kernel. The palm oil industry, in addition to producing its main product in the form of CPO, also produces solid waste, wastewater and gas emission. The purpose of this study is to identify the flow of materials, products, and non-products in the palm oil processing industry. It also aims to assess the alternatives of waste handling process, identify cleaner production opportunities that can be applied to the palm oil industry The methods used include literature studies, observations, laboratory analysis. PT MNA has treated the waste generation by reusing the solid waste formed as boiler fuel (solid waste) and land application of processed wastewater). There are still problems of waste and loss. Boiler ash is solid waste came from the combustion of fiber or pulp and palm shells in the boiler. It has a rough texture in the form of crust. The strategy for implementing cleaner production at PT MNA, has been considered technically, economically, and environmentally. By modifying the process of adding a condensate and oil water reservoir pool, could produce a B/C value = 2.5 and PBP = 0.50 years. By implementing good housekeeping could reduce dirt on the fruit with GMP (good manufacturing practice) training, having a B/C value = 1.61 and PBP = 1.63 years. By using solid boiler ash waste as a material to minimize the use of Calcium Carbonate (CaCo3) in the clay bath system*

Keywords: *cleaner production, palm oil plant, wastewater effluent, solid waste, boiler ash*

1. Introduction

Palm oil as a plant that produces oil and kernel is one of the primary plantation crops that generate non-oil and gas foreign exchange revenue for Indonesia. The bright prospects of palm oil commodities in the global vegetable oil trade have driven the Indonesian government to boost the expansion of palm oil plantation areas (Kemenperin, 2020). Palm oil has the lowest production costs of all vegetable oils in the global commodity market, and can meet the growing global demand, which is estimated to reach 240 million tons by 2050 (Corley, 2009).

According to Yanti and Lestari (2020), the area of palm oil plantations in 2019 was 2,605,026 hectares and increased to 2,801,668 hectares in 2021. The increase in palm oil plantation area can add to the amount of waste produced. In 2019, the amount of palm oil biomass waste was 20 million tons, and in 2021 it increased to 22 million tons. The increase in the area of palm oil plantations, accompanied by an increase in the number of processing industries, has resulted in more waste being generated. This is due to the increasing weight of waste from palm oil mills (PKS) that must be disposed of. The waste generated from the palm oil processing process will negatively impact the environment, including the quantity and quality of natural resources and the living environment.

Agricultural industry waste, especially from the palm oil industry, has a characteristic of high organic content (Susilawati and Supijatno, 2015). The production

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of 1 ton of fresh fruit bunches (FFB) will result in solid waste such as empty bunches (21%), shells (9%), fibers (12%) (Abnisa et al., 2013; Yanti and Lestari, 2020). Wu (2010) reported that for each ton of CPO production, liquid waste of around 2.5-3 tons is generated, while Morad et al. (2008) reported that palm oil mill liquid waste production can reach about 0.75 – 0.9 m3/t FFB. This liquid waste comes from various sources, such as boiling condensate 36% (150-175 kg/ton FFB), clarification decanter water 60% (350-450 kg/ton FFB), and hydro cyclone water 4% (100-150 kg/ton FFB) (Wu, 2010). Mahajoeno et al. (2008) reported that the analysis of palm oil mill liquid waste shows a pH of 4.4-5.4; COD of 49.0-63.6g/L; BOD of 23.5-29.3g/L; total solids of 26.5-45.4g/L, and dissolved solids of 17.1-35.9g/L. This liquid waste also contains nutrients (N, P, and K) dissolved in high concentrations. Besides solid and liquid waste, gas waste is also generated. The gas waste produced is in the form of CO2 and N2O from boiler and genset combustion (Anyaoha and Zhang, 2021).

Given the characteristics of palm oil mill waste that contains organic materials, this waste can be utilized through further processing to have high economic value. Waste processing will be beneficial not only for preventing environmental pollution but also for increasing the income of palm oil plantation businesses. According to Yulianti (2013), some examples of palm oil mill waste utilization include: as composting materials, solid waste as boiler fuel in mills, using palm oil fiber waste for liquid waste treatment, utilizing palm oil waste as composite furniture materials, utilizing gas waste, and utilizing liquid waste for biogas production.

PT MNA has a processing capacity of 60 tons of FFB/hour with its main products being palm oil (CPO) and Kernel. In the palm oil industry, PT MNA has managed the generated waste by monitoring gas waste quality in accordance with the Environmental Quality Standards (PER/GUB/SS/No.17/2005) with monitoring frequency every six months, reusing the formed waste as boiler fuel (solid shell waste), land application (treated liquid waste) as fertilizer for palm oil plants, thus the company gains benefits from these results. However, there is still waste and loss that should be minimized both quantitatively and qualitatively.

The advantages of an industry applying the cleaner production concept include reducing production costs, reducing waste, increasing productivity, reducing energy consumption, minimizing waste disposal including waste handling, and improving the value of by-products (Indrasti and Fauzi, 2009). Based on these considerations, this research was conducted to identify cleaner production opportunities suitable for the palm oil industry, thus helping to improve production efficiency in the palm oil fresh fruit bunch processing. Based on the background description and problem formulation, the objectives of this study are as follows: (1) Identify the process flow in the palm oil processing industry and waste handling process, (2) Identify cleaner production alternatives that can be implemented in the palm oil processing industry, (3) Determine the priority scale of cleaner production opportunities in the palm oil processing industry

2. Method

2.1 Data Sources

The data generated by the author is the final result of the processing during the research. Essentially, data starts from raw materials or raw data. The types of data used in this writing process are:

a. Primary Data Primary data is original data collected directly by the author. This data is gathered to address specific issues in the Practical Work report. The type

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of data used includes waste data from the clay bath obtained from PT. Multimas Nabati Asahan. (PT. MNA)

b. Secondary Data Data obtained from the Practical Work object, including profiles of PT. Multimas Nabati Asahan (PT. MNA), journals, and reference books to support related concepts.

2.2 Research Procedure

The research steps carried out include determining the experimental design, data collection, and analysis of the resulting data. The research is conducted in two stages: laboratory-scale testing and direct application testing on the clay bath unit.

3. Results and Discussions

3.1 Summary of by-products for the month of June 2023 at PT. MNA

Figure 1 depicts the increase in by-product revenue at PT. MNA. This can be analyzed due to the palm oil fruit season being very abundant, reaching up to 1,053,930 kilograms, and then experiencing a decrease of 429,980 kilograms. The data was obtained through weighing and sorting.

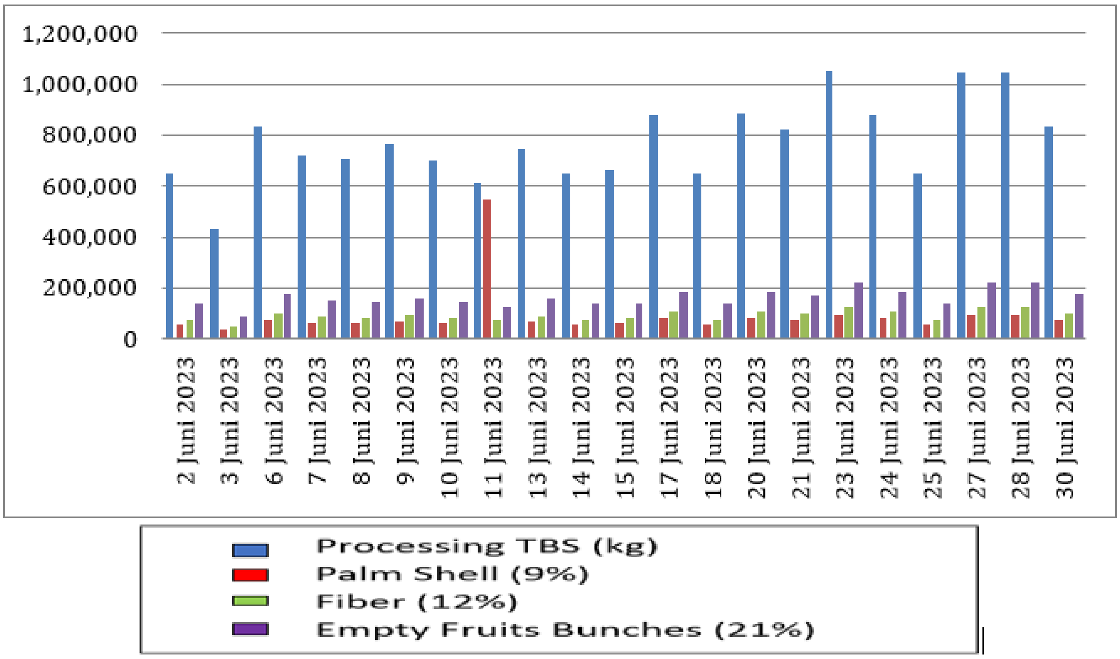

Figure 1. Summary of solids by product by June 2023

Figure 1 shows that PT. MNA only operates for half a day on Saturdays, does not process on Mondays, only receives incoming fruit at the sorting stage, and resumes activities on Tuesdays. This affects the amount of shell, fiber, and empty fruit bunches produced due to the rise and fall of incoming palm oil fruit. Shells are produced through the Thresher unit process, while fiber is produced through the fiberizing unit process, and empty fruit bunches are produced through the empty fruit bunch shredder unit process. The percentage of each by-product, such as treated palm fronds, fibers, palm shells, and empty fruit bunches, can be seen in Figure 2.

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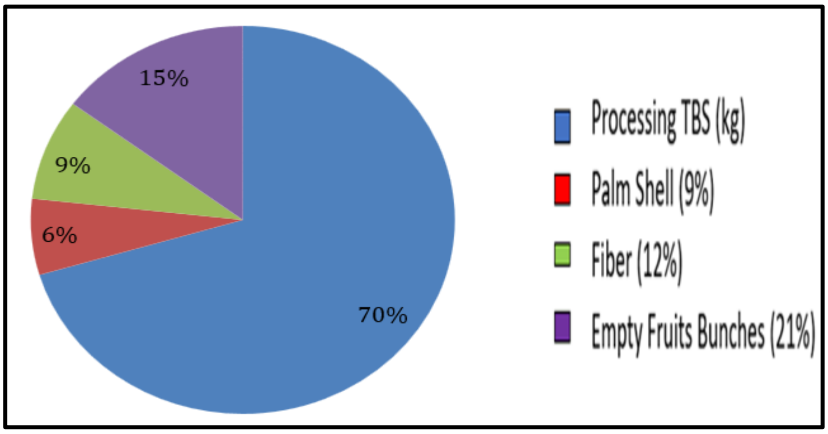

Figure 2. Percentage of solid by-product based on their types.

3.2 Processing Results of Fresh Fruit Bunches (FFB)

The procedures for processing fresh palm oil bunches are presented in Figure 3. Each step of processing produces solid by-products, which can be converted into other products using cleaner technology or cleaner production methods. Fresh fruit bunches generate five sources of solid waste: empty fronds for boiler combustion, fiber for boiler combustion, palm sludge from CPO processing for land applications, and kernel and shell waste. The kernel and shell are processed into kernel oil and kernel waste, which includes fine and coarse solid shell waste.

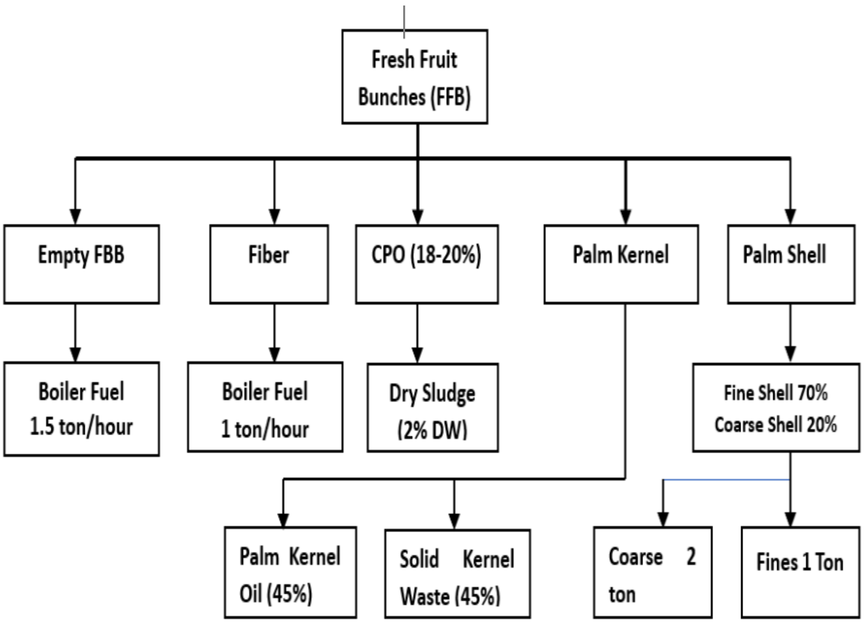

Figure 3. Fresh Fruit Bunches Processing

Based on Figure 3, fresh palm fruit bunches are categorized into five parts with different percentages: empty bunches (21%), fiber (12%), crude palm oil (CPO) (18%-20%), palm kernel (4%-5%), and shells (9%). Crude oil produces 2% dry palm sludge, while the palm kernel consists of 45%-46% kernel oil and 45%-46% kernel cake. The by-products shown in the diagram are used as boiler fuel, with usage composition detailed in Table 1.

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Tabel 1. Composition of solid by-product used for boiler combustion and its burning time

No	Solid fuel	composition
1	Shell	2 ton (Coarse shell) 1 ton (Fine shell)
2	Fiber	1 ton
3	Empty Fruit Bunch	1,5 ton
	Burning time	1 hour

Based on Table 1, it can be observed that from the total amount of fuel used for the boiler per hour, coarse shell is 2 tons, fine shell is 1 ton, fiber is 1 ton, and empty fruit bunches are 1.5 tons.

3.3 ***Utilization of Boiler Ash***

The process starts with the harvesting of Fresh Fruit Bunches (FFB) from the palm oil plantation. The fruit then goes through weighing and sorting. After that, the FFB undergoes a boiling process using three methods (1.5 barg, 2.5 barg, and 2.8 barg) for 90 minutes. This is followed by the separation of fruit, shell, and fiber, which involves several process units: Thresher (for shell and kernel), Fiberizer (for fiber and empty bunches), and clay bath (for oil from palm fruit bunches).

The next stage involves stacking the shells in a special area for reuse as boiler fuel. Using shells as boiler fuel can save the factory's expenses, and the combustion results from the shells are also very efficient for the boiler. The combustion process produces steam, which can be converted into electrical energy for the factory's needs. Additionally, the combustion produces boiler ash, which is very useful as an alternative material to replace calcium in the clay-bath machine due to its mineral and calcium content. The ash is then collected and transported into the clay-bath machine.

Palm oil shell boiler ash is ash that has undergone milling from the crust in the shell and fruit fiber combustion process at a temperature of 500-700°C in the boiler furnace, which is utilized for Steam Power Plants (PLTU). Palm oil shell boiler ash is biomass with a potential silica (SiO_2) content that can be utilized. Figure 4 illustrates the utilization and removal of boiler ash produced from solid fruit bunches and shells, which still contain high silica, as an alternative to $CaCO_3$ usage in clay bath systems. The use of boiler combustion ash as an alternative for $CaCO_3$ in the clay bath system could benefit investment capital and reduce the solid ash dumping site.

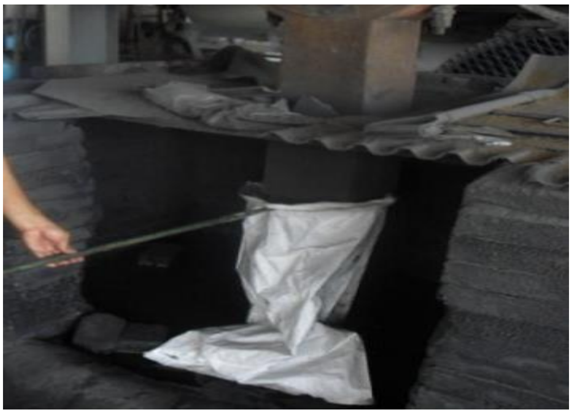

Figure 4. Emptying the boiler ash for alternative $CaCO_3$ sources

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Research by Syarifuddin et al, 2024 showed that regenerating CaCO3 waste from the clay bath unit at a palm oil processing plant has removed a remarkable oil content from the waste 75.75%. The density of the regenerated CaCO3 waste was measured at 2.467 g/mL, closely matching the fresh CaCO3 density of 2.553 g/mL. The yield of regenerated CaCO3 waste varied between 94.50% and 99.26%, this regenerated waste is anticipated to be reusable for separating palm kernels and shells.

4. Conclusions

The research compiles the opportunity for the application of cleaner production in palm oil plants, which brings us to the following conclusions:

1. Cleaner production offers optimal solutions for the environmental impacts caused by industrial processes. Besides providing greater environmental benefits compared to End-of-Pipe technology, it can also offer economic advantages.
2. Cleaner production implemented together with the Total Quality Management (TQM) program will further enhance efficiency and benefits, especially in reducing the use of materials in the process.
3. The use of boiler combustion ash as alternative for CaCo3 in clay bath system could benefit the investment capital and reducing the solid ash dumping site.

5. Acknowledgements

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