Analysis of Palm Oil Mill Effluent Quality

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Abstract. Palm oil plantations are currently growing rapidly in Indonesia. The area of palm oil plantations continues to increase from year to year. The total area of palm oil in 2022 will reach 14.99 million hectares, both privately owned plantations and PT. Pola Kahuripan Inti Sawit. To manage the yield of palm oil, assistance from the palm oil plantation industry is needed. However, the palm oil industry also produces wastewater. Therefore, researchers conducted an analysis of the quality of palm oil mill effluent. The method used in this research is exploratory method and data collection and testing is done by grab sampling. The results of the analysis contained in this palm oil mill effluent, namely the TSS content ranges from 30-40 mg/L, the pH content ranges from 7.5-8.9, BOD levels ranged from 20-300 mg/L, COD levels ranged from 30-200 mg/L, Oil and Fat levels ranged from -0.5 mg/L - 5.5 mg/L, Nitrogen (N) levels ranged from 1 mg/L - 18 mg/L. Based on AMDAL and the standard provisions of the Republic of Indonesia Minister of Environment Regulation Number 5 of 2014, all parameters tested as a whole have met national quality standards.

1 Introduction

Indonesia is one of the largest natural resource producing countries in the world, one of which is palm oil (*Elaeis guineensis Jacq.*), palm oil is a plantation commodity that plays an important role in the economy and is a source of vegetable oil [1,2]. Palm oil plantations are currently growing rapidly in Indonesia, which are spread across 24 provinces. The area of palm oil plantations continues to increase from year to year. The total area of palm oil in 2022 will reach 14.99 million hectares (ha) (BPS, 2022). To manage the results of these natural resources, assistance is needed from the palm oil plantation industry [3].
Palm oil plants have many uses, palm oil can produce various kinds of products that can be used in the food, biodiesel, cosmetic, textile and pharmaceutical industries which are useful and have high selling value [4]. However, industry also generates hazardous waste. One of the industrial wastes is water or effluent [5]. Palm oil mill effluent (POM Effluent) contains many contaminants [6] and has the potential to impact environmental pollution [7].

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Based on the explanation above, it is necessary to analyze the quality of POM effluent. This is done to find out whether the POM effluent is dangerous or not so that in the future efforts can be made to overcome the problems caused by the effluent [3]. The presence of POM effluent can have a negative impact on the environment, such as disrupting water transparency, interfering with the photosynthesis process which results in oxygen deficiency, causing tumors or death in aquatic organisms, and causing irritation, poisoning, gene mutations, and cancer in humans [8].
Analysis of POM effluent quality can be carried out using physical and chemical indicators [9]. Physics indicators are carried out by analyzing suspended solids (TSS). While chemical indicators are carried out by analyzing pH, BOD5, COD, Oil/Fat and Total Nitrogen (N). Thus, it is necessary to test TSS, pH, BOD5, COD, Oil/Fat and Total Nitrogen (N) to determine the condition of the POM effluent produced from these industrial activities [10].
The purpose of this study was to see the levels of TSS, pH, BOD, COD, Oil/Fat and N in a POM effluent that requires it to meet predetermined quality standards [11]. Quality standards are limits or levels of living things, substances or energy, other components that exist or must exist and/or elements of pollution that are tolerated according to their designation [12]. The standard for the quality of POM effluent for businesses and/or activities in the palm oil industry refers to AMDAL and the Regulation of the Minister of Environment of the Republic of Indonesia No. 5 of 2014 concerning POM effluent quality standards shown in Table 1.

Table 1. An example of a table.

Parameter	Unit	Quality standart
BOD	mg/L	100
COD	mg/L	350
TSS	mg/L	250
Oil and fat	mg/L	25
Nitrogen (N)	mg/L	50
pH	-	6 - 9

Source: Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014.

Based on the background above, the authors conducted an analysis to see the quality of this industrial effluent, where TSS, BOD, COD, pH, Oil/Fat and N are the parameters to be tested and are important parameters to determine the quality of POM effluent.

2 Method

2.1 Preliminary survey/observation

Preliminary survey is the first step before conducting research with the aim of researchers being able to obtain a general description of the location that will be used as a research location and secondary data collection [1].

2.2 Implementation Method

Observation of POM effluent is carried out using exploratory methods. Namely making observations along the path of the Effluent Ponds which will be used as a sample [13]. Collection and testing in this study were carried out from January to December 2022. Data

collection was carried out by means of grab sampling the samples taken in this study were POM effluent at the disposal of the last pond or application pond.

2.3 Identification

Identification of physical and chemical substances contained in POM effluent using results from research and standard laboratory data results, to find out and explain the levels of Quality Standards of a POM effluent that meets the requirements.

3 Result and Discussion

3.1 Total Suspended Solid (TSS)

Total Suspended Solid (TSS) measurements were carried out to determine the total suspended solids in POM Effluent. The frequency of observing TSS parameters in palm oil mill effluent will be carried out per month in 2022 [14,15,6].

Fig. 1. Graph of analysis results of Total Suspended Soil (TSS) of POM Effluent from PT. Pola Kahuripan Inti Sawit

Based on Figure 1, the results of the TSS analysis of palm oil wastewater as a whole are between 30 mg/L – 40 mg/L. The results of the TSS analysis are classified according to the quality standards that have been set because they are below 250 mg/L. In the past 12 months, there has been no significant jump in TSS levels, but in June it has increased to 90 mg/L. It is because of wheather condition at site.

3.2 pH

pH measurement was carried out to determine the acid value and alkaline value contained in POM Effluent. Measurement of the pH was carried out using a pH meter [6]. This is done in order to know the pH value in POM Effluent, if the pH is acidic it results in pollution which can reduce water quality [16]. The frequency of observing pH parameters in POM Effluent is carried out per day.

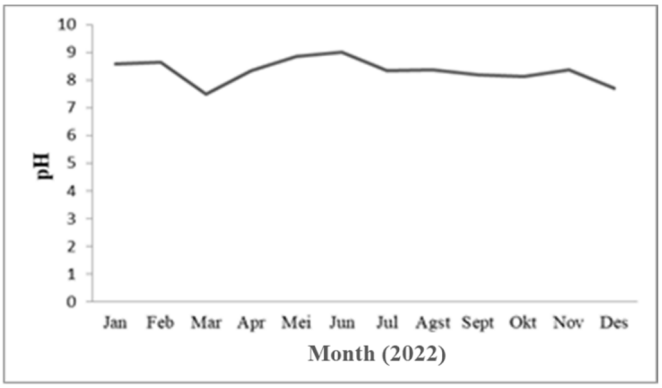

Fig. 2. Results of pH analysis of PT. Pola Kahuripan Inti Sawit

Figure 2 shows the results of the pH analysis of PT. Pola Kahuripan Inti Sawit. Figure 2 shows the pH value in the January-December 2022 period ranging from 7.5 – 8.9. The pH value is already at the environmental quality standard threshold, namely pH 6 – 9. In Figure 2 it can also be seen that the pH has been relatively constant for 12 months. In March the pH value decreased due to weather factors in the field.

3.3 Biological Oxygen Demands (BOD)

One of the parameters that is often measured in seeing the performance of the POM Effluent is Biological Oxygen Demand (BOD). BOD (Biological Oxygen Demand) is a property or characteristic that shows the amount of dissolved oxygen, or a relative measure of the amount of oxygen. This oxygen is oxygen needed by microorganisms (bacteria) to oxidize or decompose organic matter under aerobic conditions [18]. The frequency of BOD observations in POM Effluent is carried out per month.

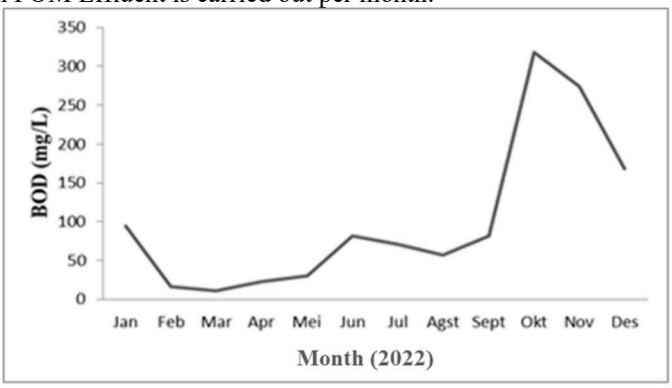

Fig. 3. Graph analysis of BOD analysis of POM Effluent from PT. Pola Kahuripan Inti Sawit.

The results in Figure 3 show that the Biological Oxygen Demond (BOD) levels have fluctuating values every month. However, in the past 12 months, there has been a significant increase in October, because this month factory waste has high levels (BOD), this occurs because the weather this month is unpredictable and makes the waste in the holding ponds become cloudy. However, the overall BOD value of PT. Pola Kahuripan Inti Sawit already meets environmental quality standards. The results of the BOD test turned out to be quite consistent with the results obtained by Nabilah [6] which stated that effluent from palm oil mills usually contains dissolved solids in the form of colloids and oil residue

so that they have BOD and Chemical Oxygen Demand (COD) values. tend to be high [19,20].

3.4 Chemical Oxygen Demand (COD)

COD (Chemical Oxygen Demand) is the amount of oxygen needed to decompose all organic matter contained in water such as ammonia and nitrites [9]. The higher the level, it means that these substances are still in large quantities and are dangerous if disposed of directly into the environment. COD testing is necessary because it is a parameter in POM Effluent quality standards. This shows that COD is a parameter in water pollution. The frequency of observing the COD parameter in POM Effluent is carried out per month.

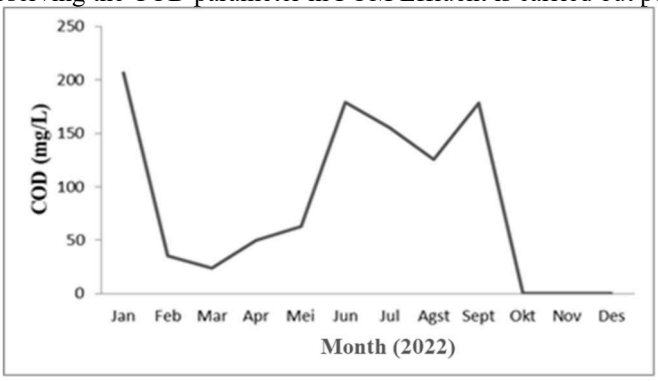

Fig. 4. Graph analysis COD analysis of POM Effluent PT. Pola Kahuripan Inti Sawit.

From Figure 4 it can be seen the results of the COD analysis of POM Effluent from PT. Pola Kahuripan Inti Sawit. Overall, it is in accordance with the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014 concerning POM Effluent quality standards, the COD level set for POM Effluent is 350 mg/L. The test results for the past 12 months show a fluctuating value every month and no spikes that are too high, because the content of organic matter that is biologically decomposed is quite large.

3.5 Oil and Flat

Oil and fat analysis was carried out to determine the amount of oil and fat content remaining from the processing of palm oil. The measurement of the oil and grease content of POM Effluent was carried out using the Soxhlet method [21]. Oils and fats have properties that do not mix with water and float to form a thin layer that blocks the entry of sunlight which results in a reduced rate of photosynthesis in the water. This causes disruption of the aquatic ecosystem [22].
In addition, the presence of a layer of oil and grease will limit the oxygen that enters the water so that it will kill living things in the water due to a lack of oxygen intake [23]. The frequency of observing the parameters of oil and fat content in POM Effluent is carried out per month.

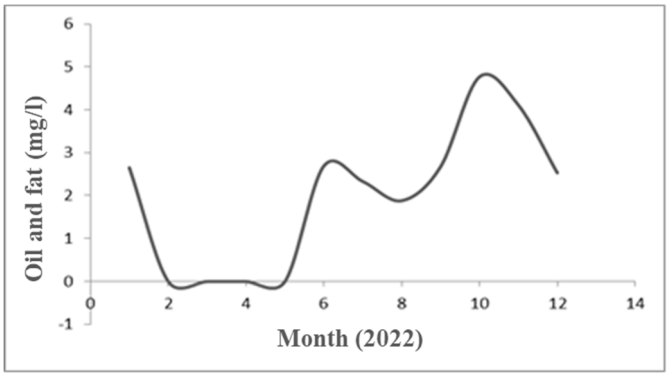

Fig. 5. Graph analysis analysis of Oil and Fat in POM Effluent PT. Pola Kahuripan Inti Sawit

Based on the results shown in Figure 5, it can be seen that the levels of oil and grease in POM Effluent from January to December 2022 ranged from -0.5 mg/L - 5.5 mg/L. Overall the levels of oil and grease in wastewater at PT. Pola Kahuripan Inti Sawit already meets environmental quality standards based on Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014 concerning Quality Standards of POM Effluent for Industrial Activities, which is less than 30 mg/L. There was a decrease in the oil and grease content in the wastewater from February to April and after that the oil and grease content in the wastewater was relatively constant.

3.6 Nitrogen (N)

Nitrogen is a non-metallic chemical element that has an atomic number of 14 in the periodic system, each atom having five valence electrons in the ns2n p3 configuration. In nature, the element nitrogen is found land in the air, sea and land. Apart from being in gaseous form, this chemical element can exist as a form of compound with other elements to form new compounds that have different chemical properties from the elements [24].
The content of nitrogen in water in the form of Ammonia (NH_3), Nitrate (NO_3) and Nitrite (NO_2) greatly affects the quality of a body of water. Nitrogen cycles that occur in a body of water sometimes consume the most dissolved oxygen compared to other biochemical reactions that occur in water [25].

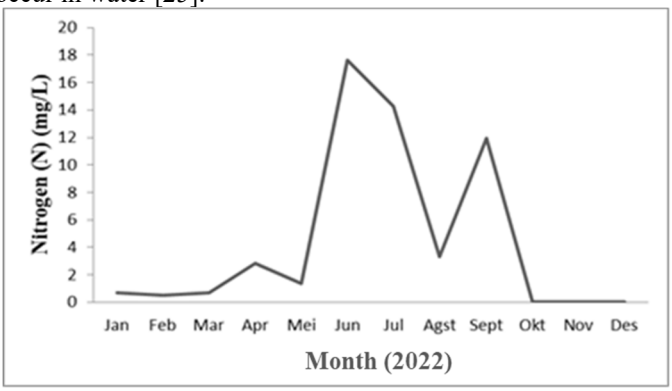

Fig. 6. Graph analysis of Nitrogen (N) analysis in POM Effluent from PT. Pola Kahuripan Inti Sawit

Based on the results shown in Figure 6, it can be seen that the N content in POM Effluent from January to December 2022 ranges from 1 mg/L - 18 mg/L. Overall the level of N in wastewater at PT. Pola Kahuripan Inti Sawit pattern already meets environmental quality standards based on the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014 concerning POM Effluent Quality Standards, which is less than 50 mg/L. An increase in N levels in POM Effluent can occur because palm oil fruit contains N which comes from soil in palm oil trees [26].

3.7 Analysis of Liquid Waste Parameter Data

At this stage, the frequency distribution and numerical distribution test (normality) were carried out on the parameter data of the first pond of PT.Pola Kahuripan Inti Sawit of POM Effluent and using SPSS. Because the data is less than 50 ($n < 50$), the analytical method uses Shapiro-Wilk, where $p > 0.05$ is considered normally distributed data [27]. At the pH value of the factory laboratory (pHint) and the pH of the government laboratory (pHext) a different test (T-Test) was carried out with a significant $p = 0.000$ ($p < 0.05$).

Table 2. Frequency Distribution and Normality Test of the First Pond of PT. PKIS.

Parameter	Minimum	Maximum	Means	Normality test	Data Distribution
pHint	3.86	4.81	4.2800	p=0.393	Normal
pHext	3.91	4.78	4.4067	p=0.053	Normal
BOD	6,427.40	41,702.00	24,186.33	p=0.266	Normal
COD	14095.40	91,452.00	51,785.91	p=0.140	Normal
Oils & Greases	0.01	1371.80	721.36	p=0.528	Normal
TSS	105.50	17,500.00	6831.03	p=0.523	Normal
Total N	17,20	590.10	133.45	p=0.000	Abnormal

Source: Processed data, 2023.

The pH value at the factory laboratory (pHint) and the pH of the government laboratory (pHext) was subjected to a different test (T-Test) with a significance $p = 0.366$ ($p > 0.05$). These results show ***there is no*** significant difference in average pH between pHint and pHext of the first pond of PT.Pola Kahuripan Inti Sawit.

3.8 PT PKIS Application Pond

At this stage, a frequency distribution and a numerical distribution (normality) test will be carried out on the parameter data of the PT PKIS application pond of POM effluent and the SPSS application will be used for testing. Because the data is less than 50 ($n < 50$), the analytical method uses Shapiro-Wilk, where $p > 0.05$ is considered normally distributed data [27].

Table 3. Frequency Distribution and Normality Test of PT. PKIS Application Pond.

Parameter	Minimum	Maximum	Means	Normality test	Data Distribution
phint	7,37	8.34	7,71	p=0.031	Abnormal
phext	7,71	8.45	8,25	p=0.030	Abnormal
BOD	57,41	1206.00	470,16	p=0.093	Normal
COD	125.89	3.145,20	11.37,78	p=0.204	Normal
Oils & Greases	1.88	77,16	18.52	p=0.003	Abnormal

Source: Processed data, 2023

For factory laboratory pH values (pH int) and government laboratory pH values (pHext) a non-parametric paired mean test was performed (*Wilcoxon Signed Ranks Test)* with significant p = 0.003 (p <0.05). These results indicate that there is a significant difference in the mean pH between pH int and pH ext of the PT PKIS application pond. This difference occurs because the application pond is the first pond for waste disposal leaving the palm oil processing factory. Therefore, in the application pool, pH int and pH ext have different values and different averages.

3.9 PT PKIS Effluent Analysis

To see that the effluent treatment has been carried out properly, a statistical analysis of the parameters of the first pond and the application pond is carried out. For pairs of normally distributed data, an unpaired T-test was performed. For pairs of data that are not normally distributed, a transformation test is performed first. If the data is still not normally distributed, then proceed with a numerical mean test for 2 independent groups, with one group of data not normally distributed (Mann-Whitney Test).

Table 4. Data on the difference between the first pond and PT. PKIS application pond

	Parameter	Mann-Whitney Test	T-Test
phint	First Pond	p = 0.000	
	Application Pond		
phext	First Pond	p = 0.000	
	Application Pond		
BOD	First Pond		p = 0.000
	Application Pond		
COD	First Pond		p = 0.000
	Application Pond		
Oils & Greases	First Pond	p = 0.001	
	Application Pond		

Source: Processed data, 2023

From the table above it can be seen that significant p <0.05 so that there is a significant difference in the mean between the parameters of the first pond and the PT PKIS application pond.

Table 5. Analysis of the pH, BOD and COD values of the Application Pond compared to the standard values for PT. PKIS

Parameter	Amount of data	As per standards	Subpar	Top standards
pHint	12	100%	-	-
pHext	12	100%	-	-
BOD	12	-	100%	-
Oils & Greases	12	75%	-	25%

Source: Processed data, 2023

In table 5 it can be seen that all pHint and pHext parameters are in accordance with the standards. The BOD parameters are all below standard. The circulation of sewage ponds is not good enough. Supervision must be tightened so that officers work in accordance with existing standard operating procedures. Low BOD results in less nutrient content of liquid waste that is applied to estate.
For oil & grease parameters 75% according to standard and 25% above standard. This indicates that the process in the anaerobic pond has not gone well so that the bacteria cannot optimally utilize the existing liquid waste feed. It is necessary to ensure that the feeding arrangements for all ponds under flow are in accordance with existing operational standards so that in the application pond all parameters are in accordance with the standards.

4 Conclusion

The results of the analysis contained in this POM effluent are TSS content levels ranging from 30-40 mg/L, pH content ranging from 7.5-8.9, BOD levels ranging from 20-300 mg/L, COD levels ranging between 30-200 mg/L, Oil and Fat levels range from -0.5 mg/L - 5.5 mg/L, Nitrogen (N) levels range from 1 mg/L - 18 mg/L. Based on the standard provisions of AMDAL and the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014. Overall, it has met the national quality standards.

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