Water Quality Testing Due to Oil Palm Plantation Activities in Bangka Regency

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Abstract. Agricultural activities are one of the main income sources in Bangka Regency, but this activity also provides a dilemma for environmental conservation. Oil palm plantation activities always use fertilizers and pesticides, leaving organic contamination in the waters. Cases of poisoning against pesticides, especially organophosphate groups, have been widely reported. To avoid that preventive measures are required, so we must know the water quality and pollution load that contained in the water around the area of oil palm plantations. This study aims to monitor water quality based on chemical parameters (DO, BOD, COD, nitrate and phosphate levels), and the presence of pesticide residues in the waters around oil palm plantations in Bangka Regency. The results showed waters around oil palm plantations in Zed meet mild to moderate pollution (3.21-4.95 mg/L) based on DO parameters, meet class II water quality standards for BOD (2.37-2.68 mg/L), COD criteria (8.7-11.4 mg/L), nitrate (0.985 mg/L) and phosphate (<0.0313 mg/L). Waters around oil palm plantations in Sempan meet moderate pollution based on DO parameters (3.59-3.78 mg/L), and meeting the class II water quality standards for the criteria of BOD(2.37-2.47 mg/L), COD (8.68-9.56 mg/L), nitrate and phosphate. The results did not found any pesticide organophosphate residue.

1. Introduction
Agricultural activities are one of the main livelihoods in Bangka regency. Currently, the primary agricultural commodities in Bangka Belitung Archipelago are peppers, rubbers, palm oils, and coconut. Palm oil has begun to become a leading commodity in recent times. According to the Central Bureau of Statistics data, the number of oil palm plantations in Bangka Belitung Archipelago increase continuously from 2001 to 2015, there are 41 large plantations. The dilemma of economic development versus environmental degradation, especially water quality caused by fertilization and pesticide use in palm oil plantation.

Agriculture Ministry data in 2014 mention that the number of registered pesticides is 3005 brands with most of them are organophosphate compounds. Organophosphates are toxic pesticides and insecticides that will cause humans poisoning. Organophosphate poisoning symptoms are generally non-specific and even tend to resemble the symptoms of common diseases. These diseases can include dizziness, nausea, and weakness so that people consider illnesses that do not require particular therapy. These cases can be prevented if the public knows the impact of distribution after the use of fertilizers and pesticides in the waters of the plantation area. Thus, the use of water resources in palm oil plantations area can consider the distribution of existing organic contaminants.
Oil palm plantation activities are estimated to not only contribute to contamination from the use of pesticides but also fertilization. Fertilizer is a plant fertilizing material and is categorized as a pollutant source because of the content of individual elements and compounds that enter into a system [1]. Fertilizing oil palm plants is carried out during the life of the plant. Fertilization activities generally use chemical fertilizers such as KCl, urea, ciserit, and Triple Super Phosphate (TSP). Faizal et al. [2] mention one source of nitrates in the waters, namely agricultural and aquaculture activities that use inorganic and organic fertilizers such as TSP. The results showed that the use of fertilizers by farmers tends to be excessive. The range of use of urea (N) fertilizers is 100-800 kg/hectare, and P and K fertilizers are 0 - 300 kg/hectare and 0-250 kg/hectare [3]. The residual fertilizer can seep into the soil and contaminate groundwater.

Until now, there are no research publications that focus on monitoring pollution, water quality in the area of oil palm plantations, and control efforts based on organic contamination data on agricultural activities in Bangka Regency. So there needs to be a preliminary study on monitoring water quality and biological contamination to determine the water quality in the area of oil palm plantations in Bangka Regency. This preliminary data can be used as a reference in compiling environmental control policies and actions. This study aims to determine water quality based on presence of organic contamination and organophosphate groups pesticide residue in the area of oil palm plantations.

2. Materials and Methods

2.1 Study area
The study area included the waters around the oil palm plantations in Zed and Sempan village, Bangka district. (Figure 1).

2.2 Sample Collection
Water samples were taken using polyethylene bottles. The number of water samples taken at each sampling point is around 2L; then the water sample is put into a polyethylene bottle and stored in the Laboratory. After transportation to the laboratory, water samples were stored at refrigerator and extraction. Sampling was carried out on November 14th, 2018. Samples were analyzed in laboratories.

2.3 Chemicals and Instrumentation
Instrument equipment GC-MS model QP2010. The materials used in this study: water samples from Zed and Sempan village, diethyl ether, n-hexane, phosphate buffer solution pH 7, sodium sulfate. The solvents used for extraction i.e., diethyl ether and hexane, were obtained from Merck.

2.4 Analytical Procedure
2.4.1 Water Sampling. Water samples are taken using bottles. The number of water samples taken at each sampling point is around 2L; then the water sample is put into a polyethylene bottle and stored in a coolbox, then taken to the Laboratory.
2.4.2 **Determination of Water Quality Parameters.** Determination of DO, BOD, COD phosphate and nitrate parameters follows the Standard Nasional Indonesia (SNI) procedures:

- How to Test dissolved oxygen using DO meter SCHOTT Instruments.
- SNI 6989.72: 2009 Water and wastewater - Part 72: How to Test Biochemical Oxygen Demand (BOD) Requirements [4].
- SNI 6989.72: 2009 Water and wastewater - Part 73: How to Test Chemical Oxygen Demand (COD) [5].
- SNI 6989.31: 2005 Water and wastewater - Part 31: How to Test Phosphate by Spectrophotometer in Ascorbic Acid [6].
- SNI 6989.79: 2011 Water and wastewater - Part 79: How to Test Nitrate (NO₃-N) by UV-Visible Spectrophotometer in Cadmium Reductions [7].

2.4.3 **Determination of Pesticides Residues in Water Samples.** 100 mL of the water sample is put into a separating funnel add a solution of 20 mL diethyl ether and shaking for 2 minutes. The sample is left until there is separation (two layers are formed). The bottom layer is put back into the separating funnel, and repetition is carried out, then the organic layer joins the glass container. The bottom layer is reinserted into the separating funnel, then an n-hexane solution (20 mL) is added, and shake for 2 minutes. Let it separate, and the bottom layer is removed, while the top layer is combined with the other top layer in container glass. The organic layer was dried using a rotary evaporator, then added 5 mL n-hexane and anhydrous sodium sulfate to separate the remaining water. Samples are ready to be analyzed by Gas Chromatography-Mass Spectroscopy (GCMS) [8].

3. **Results and Discussion**

Samples were taken at two locations Zed Village and Sempan Village. These locations represent young palm oil plantations (Zed Village) and old age oil palm or already producing plants (Sempan Village). In Zed village, sampling was conducted at four points. Each sample was labeling station 1, which is the upstream part of the water with a distance of approximately 4 meters from the nearest oil palm plant. Station 2 is about 30 meters from station 1, and station 2 has a distance from the nearest oil palm plant which is approximately the same as station 1. Station 2 is also used to farmers’ bath. Station 3 is the closest to an oil palm plant with a distance of fewer than 2 meters. Station 4 is located in the downstream area of water with a distance of about 2 meters from the nearest oil palm plantations. Sampling using the grab method (temporary sample) was taken on August 14, 2018.

The results of measurements of water quality parameters are presented in Table 1.

**Table 1.** The water quality parameters measurement result

| Sample Name  | pH | DO (mg/L) | COD (mg/L) | BOD (mg/L) | Nitrate (mg/L) | Phosphate (mg/L) |
|--------------|----|-----------|------------|------------|----------------|------------------|
| Station 1 Zed | 5  | 4.93      | 9.65       | 2.47       | 1.2            | < 0.0313         |
| Station 2 Zed | 5  | 4.55      | 8.70       | 2.37       | <0.50          | < 0.0313         |
| Station 3 Zed | 5  | 3.21      | 10.4       | 2.68       | 1.10           | < 0.0313         |
| Station 4 Zed | 5  | 3.85      | 11.4       | 2.58       | 1.14           | < 0.0313         |
| Station 1 Sempan | 5  | 3.59      | 9.56       | 2.47       | 0.745          | < 0.0313         |
| Station 2 Sempan | 5  | 3.78      | 8.68       | 2.47       | 0.985          | 0.0339           |
| Station 3 Sempan | 5  | 3.75      | 9.14       | 2.37       | 0.735          | 0.0574           |

Measurement of Dissolved Oxygen was done using DO meter instrument. The aim is to determine the number of bacteria or organic waste that are degradable in the waters indirectly. Free oxygen in water can be reduced if there is a degradable organic waste. We can see from the results that the DO value in water samples from Zed village is low, which means there is a large decrease in dissolved oxygen levels. Low oxygen levels are caused by the increasing activity of microorganisms in decomposing organic substances into inorganic substances that use dissolved oxygen. More organic
waste in the water, the less oxygen is dissolved in it. The tendency to decrease dissolved oxygen in these waters is strongly influenced by the increase of organic materials entering the waters [9].

Water quality criteria based on dissolved oxygen (DO) levels are shown in Table 2. Based on these criteria, the pollution that occurred in the Zed oil palm plantation area was categorized as mild and moderate. Whereas all sample from Sempan are categorized as moderate polluted.

| Dissolved Oxygen (DO) mg/L | Criteria         |
|---------------------------|------------------|
| > 6.5                     | Not polluted     |
| 4.5 - 6.4                 | Lightly polluted |
| 2 - 4.4                   | Moderately polluted |
| < 2                       | Heavily polluted |

Biochemical Oxygen Demand is a measure of the amount of organic matter that can be oxidized by aerobic bacteria/the amount of oxygen used to oxidize a certain amount of organic matter in an aerobic state. Indirectly BOD states the amount of organic contamination that can be decomposed in measured waters. In Zed sample, there are regularity measurement results of BOD and COD values toward the distance of the location of water sampling to oil palm plantations. Station 4 of Zed village is the location closest to the oil palm plantations, so it has the highest BOD and COD value compared to other stations. Besides, this high value can also be caused by the accumulation of organic impurities because this station is the estuary of irrigation.

The BOD requirements permitted in Indonesia based on the Government Regulation of the Republic of Indonesia Number 82 year 2001[11] for class II water are 3 mg/L. This means that all of the samples meet the quality standards for Class II water. However, BOD value in all samples is classified as high and close to the upper limit set so that control measures need to be considered. The water in the sample site is not only used as irrigation to oil palm plants, but also as a bathing place. This should be the basis for reviewing the accuracy of water use in the region.

COD is the total amount of oxygen needed to chemically oxidize organic matter, both biologically and degraded to CO₂ and H₂O. The COD value obtained from the measurement states whether organic contamination can or not decomposed by bacteria [12]. The COD value was monitored in the oil palm plantation area of the village of Zed 8.7-11.4 mg/L. This value meet the standard quality provisions for class II water (25 mg/L) but does not meet the criteria for class I water which requires a maximum COD value of 10 mg/L. The highest COD value is come from station 4 sample, which is aquatic estuaries.

3.1 Nitrate and Phosphate Parameters

Oil palm plantation activities are estimated contribute to the contamination not only from the use of pesticides but also fertilization. Fertilization of oil palm plants is carried out periodically both on plants that are still new (not yet productive) to productive plants. Fertilization activities generally use chemical fertilizers such as KCl, urea, kisierit, and TSP. According to Faizal et al. [2], aquaculture activities use inorganic and organic fertilizers such as TSP, urea, and manure, which are one of the sources of nitrates in the waters.

Table 1 shows the highest nitrate in the upstream waters. Nitrate levels that are slightly higher at station 1 near the bottom of the water are also affected by sediment. N and P-type nutrients are the main parameters needed in the process that takes place inside the body of phytoplankton (physiological processes). Phytoplankton activities such as metabolic processes and growth can take place optimally if the availability of these elements is met. Also, nitrates and phosphates in the waters will also be absorbed and used by phytoplankton in carrying out photosynthesis [13].

Nugroho et al. [14] said quantified level of water fertility based on nitrate content 0.1 - 0.25 mg/L called oligotrophic waters (weak fertility), 0.26 –0.50 mg/L called mesotrophic waters (moderate fertility) and above 0.51–0.75 mg/L is called eutrophic waters (high fertility). Water samples taken from Zed have an average nitrate level of 0.985 mg/L, which means very high or hypertrophic. The maximum level allowed for nitrate and nitrite is divided into four water classes. Nitrate for class I and II maximum
levels of 10 mg/L while for class III and IV the maximum level is 20 mg/L. The waters studied are waters designated for irrigation of plants and baths which are included in class II water. So that nitrate levels in the waters studied meet the quality standards and do not danger the designation.

The total phosphate parameters in Zed village were observed to be at low levels, all of which were under 0.0313 mg/L while the quality standard for phosphate parameters was 0.2 mg/L. This shows that the dissolved phosphate in the combustion is quite small. Phosphate can be derived from residual fertilization, so that if a small total phosphate value indicates that fertilizing using phosphate does not affect the state of water during monitoring.

We compared the results of the total phosphate in Sempan and Zed; the value in Sempan village is higher. This is because the residual phosphate due to fertilization has been neglected in the larger range, which is directly related to the larger fertilizer dosage. The average fertilizing dose for immature plants is 0.4-0.6 kg per plant. Whereas for plants producing 2.5 kg per plant. The rest of the fertilizer is washed away into the waters around oil palm plantations.

3.2 Pesticide Residues in Waters
Pesticide residue examination aims to determine whether pesticide residues reach water bodies and affect the aquatic environment due to agricultural activities, in this case, oil palm plantations. Pesticide residues can reach the aquatic environment through direct runoff, washing, and empty container disposal, washing equipment, and others (Milindis, [15]).

Based on a survey with farmers, measurements of pesticide residues were only carried out for Zed villages and were not carried out for Sempan village. According to the information from farmers in Sempan village, which is a yielding plant, it no longer uses pesticides. The results of pesticide residue measurements are as follows:

| Peak | R.Time | Name                  |
|------|--------|-----------------------|
| 1    | 1.411  | Ethyl ether           |
| 2    | 1.482  | 2-Methylpentane       |
| 3    | 1.506  | 3-Methylpentane       |
| 4    | 1.532  | n-hexane              |
| 5    | 1.607  | Methylcyclopentane    |
| 6    | 1.705  | Hexanaphentane        |

Retention time (RT) compared to reference for organophosphate (Methyl-Parathion) pesticides. According to Leena et al. [16], RT values for Methyl-Parathion compounds were 4.64 minutes. While in Table 3., the same RT is not found. The results of this comparison indicate that there is no RT match between the sample and the RT Methyl-Parathion. The following is the structure of methyl parathion showed in Figure 2. Fractionation that formed from MS analysis showed no match for a fraction with the methyl-parathion structure shown in Figure 2. so that methyl-parathion pesticide residues were not detected in the sample.

4. Conclusion
Water Quality around the oil palm plantation area in Bangka Regency based on chemical parameters in Zed meet mild to moderate pollution is based on DO parameters, meeting class II water quality standards for the criteria of BOD, COD, nitrate, and phosphate. Sempan samples is meeting moderate pollution.
based on DO parameters, meeting class II water quality standards for the criteria of BOD, COD, nitrate, and phosphate.

No residues of Methyl Parathion (an organophosphate pesticide) were found in the waters of the oil palm plantation Zed area. The nitrate runoff level in the waters of Zed village is classified as hypertrophic. In Sempan, phosphate levels are classified as eutrophic. Fertilizing activities are more dominant to contribute to the contamination of water around the oil palm plantations monitored area.

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