Characteristic of non-point source biochemical oxygen demand from agricultural land in the part of Code River

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Abstract. Non-point source (NPS) is one of the global issues dealing with water quality. This pollutant source contributes a lot to pollution and it is relatively hard to control. Agricultural land is one kind of NPS. Cultivation activities that aim to prepare land for the crop planting could increase the potency of pollution load. It is important to know the characteristic of pollution load in agricultural land. The amount of pollution load in agricultural land tends to be fluctuating. The objective of this study is to know the characteristic of pollution load in agricultural land. The method used in this research is the statistic test. Scatterplot as a data presentation technique. The independent variable used in the statistic test is the interval between the last rain and the time of sampling ($X_1$), the thickness of the rain ($X_2$), and the discharge ($X_3$). Test $F$ shows that the independent variable gives simultaneous influence to the concentration of BOD in agricultural land. Test $T$ shows that the influences every independent variable to the concentration of BOD. The relation between the concentration of BOD ($Y$) and the independent variable is formulated as follow: $Y = 0.810 - 0.160 X_1 - 0.490 X_2 + 21.704 X_3$. Pollution load of NPS is temporally fluctuating. The maximum pollution load from agricultural land happens when the rainfalls. In normal condition, the pollution load is minimum.

1. Introduction
There are two types of pollutant source, point source and non-point source (NPS) [1]. A point source is easier to be noticed, such as an outlet of industrial waste. Therefore, it is easier to be identified, counted, and controlled [2]. Non-point source spreads and is transported by runoff. This kind of pollutant source affected by many factors and tends to be complex. It has a big impact on pollution because it is relatively hard to control. Other than that, NPS has become a global issue in terms of water quality [3]. In studying water quality, NPS pollution load application usually uses the estimate from emission factor [4]. The determination of the value of emission factor is general and does not tend to pay attention to regional characteristics. The value is obtained from the previous research or adopted from the value of emission factor in another country with the similar situation [5].

Agricultural land is one example of NPS. Land use approach is one of the ways to know the characteristics of a pollutant [6,7, 8, 9]. Pollution that comes from agricultural land has been a serious problem, like what has happened in Iran and China [10,11]. Cultivation activities that aim to prepare land for the planting of the crop could increase the potency of erosion. When rain falls, the runoff will bring soil, along with its nutrients, to the river. Other than that, the waste from agricultural activities
will pollute both the water and the water resources. It can decrease water quality status, water quality status is determined by the government to manage water quality [12]. The intensive use of fertilizer will result in eutrophication. Therefore, it is important to know the characteristics of pollution load in agricultural land.

The identification of pollution load characteristics in agricultural land uses Biochemical Oxygen Demand (BOD) water quality parameter. BOD is a parameter that is frequently used by the Ministry of Environment and Forestry when determining the amount of pollution load in a segment of the river. From 1980ish until 1990ish, there is an increased indication of water quality degradation in Code River [13]. It can be seen from the increase of the concentration of BOD and the decrease in concentration of DO (Dissolved Oxygen). This condition is confirmed by the data from Environmental Services of D.I. Yogyakarta in 2016 about the monitoring of BOD water quality. The concentration of BOD exceeds the standard quality of river water class 2 (3 mg/l). The concentration of BOD in Boyong, Pakem, is 9,5 mg/l (February, 2016), 5,3 mg/l (May, 2016), and 8,16 mg/l (September, 2016). The location of monitoring is on the upstream of Code River, after agricultural land. Water quality is a very lucrative parameter because there are many factors that give influence to it [14,15]. The objective of this study is to know the characteristics of NPS pollution load in agricultural land. The result of this research can help to determine the value of emission factor for BOD pollution load in agricultural land and give a recommendation about the time of water sampling.

2. Data and methods

2.1. Data

Variables that are utilized to identify the characteristics of pollution load in agricultural land are the interval between the last rain and the time of sampling \(X_1\), the thickness of the rain \(X_2\), and the discharge \(X_3\). There are two kinds of data used in this research; primary and secondary. Primary data comprises water quality monitoring and discharge, while secondary data comprises rainfall data. The rainfall data is obtained from radar imagery monitoring in Yogyakarta. It is obtained from Hydraulics Laboratory UGM. Pollution load monitoring comprises water quality monitoring and discharge. The sample represents how the condition is, either in the rainy or dry season. A laboratory test is conducted to know the BOD water quality, whereas the measurement of discharge flow uses velocity-area method. This method is suitable for the river irrigation channels whose flow is relatively low. The measurement of a cross section of a river uses the trapezoidal rule, whereas the measurement of flow uses float. The discharge flow calculation is summarized in equation (1).

\[
Q = K x V x A
\]  
(1)

Where,

\(Q\) = discharge (m\(^3\)/s)

\(A\) = cross-sectional area (m\(^2\))

\(V\) = flow velocity (m/s)

\(K\) = float coefficient, the coefficient calculation is summarized in equation (2)

\[
K = 1 - 0,116 \sqrt{1 - \frac{a}{b} - 0,1}
\]  
(2)

Where,

\(a\) = the length of the stalk that enters the water (m)

\(b\) = water depth (m)
2.2. Research method

2.2.1. Statistic Test

The analysis of the relation between the interval (X₁), the thickness of the rain (X₂), and the discharge (X₃), uses the SPSS program. Those variables play a role as an independent variable, whereas the dependent variable is the concentration of BOD (Y). Statistic test that is used tests T and test F. Test T, or partial test, is conducted to know the relation between each of those independent variables and the dependent variable, whereas test F, or ANOVA test, is conducted to know the simultaneous relationship between the independent variable and the dependent variable. In this research, the level of significance that is used is 5%, which means there is a potential error as big as 5%. The result of the test (T count and F count) is compared with the value of T table and F table. If T count and F count are bigger than T table and F table, we can conclude that independent variable affects dependent variable, and vice versa. The coefficient of determination (adjusted R square) is also used in simple regression analysis. Its intention is to know the percentage rate. The equation of multiple linear regressions is as following equation (3) [16].

\[ Y = a + b_1X_1 + b_2X_2 + b_3X_3 \]  

Where,

- Y = dependent variable
- X = independent variable
- a = constants
- b = regression coefficient

2.2.2. Analysis of loading pollution characteristic

The pattern of data distribution, which shows the relation between an independent variable and the dependent variable, is analyzed by scatterplot. Scatterplots time interval vs water quality, rainfall vs water quality, and discharge vs water quality. After that, the regression model from each scatterplot is shown through the coefficient of determination (R²). If the independent variable is closer in value to 1, it means that the independent variable impact the dependent variable or the concentration of BOD. The pattern of the concentration of BOD in time series and the condition during time sampling are things that should be considered in determining the characteristics of BOD pollution load in agricultural land.

3. Result

There are two locations of NPS pollution load monitoring; location of the upstream control point (T1) and location of the downstream control point (T2). Administratively, the research site is located in Candibinangun, Pakem, Sleman, D.I. Yogyakarta (see figure 1). T1 has the coordinate 49 M 434072 mT and 9154496 mU. It has a coverage area of 0.085 km² and length river is 645.9 meters. The parameter that is used to know the water quality is Biochemical Oxygen Demand (BOD). BOD is one example of chemical parameters to know the water quality. It is related to organic matter content in water. There are two types of organic matter decomposition process [12]. First is the decomposition process that turns organic content into inorganic content. Second is the decomposition process that turns unstable inorganic content into stable inorganic content. The determination of BOD value is based on the first type of decomposition process, which means it is based on the amount of oxygen that is needed to oxidize organic content into inorganic one (carbon dioxide and water). BOD value in water that contains toxicants tends to be not suitable, as the toxicants could kill microbe and could be decomposed into inorganic content [17].
Crops that grow in the monitoring location are rice, thorny palm, and kolonjono. The pollutant source in agricultural land could come in the form of fertilizer and sediment. Fertilizer content could come in the form of the main nutrient (P\textsubscript{2}O\textsubscript{5}), secondary nutrient (Ca and Mg), micronutrient (Fe, Mn, Cu, and Zn), and contains elements of heavy metal. The monitoring of BOD water quality in agricultural land is conducted in two monitoring points; upstream and downstream. Other than spatially, the monitoring is also done temporally. The sample represents the condition of the rainy and dry season.

The monitoring of BOD water quality in agricultural land can be seen in Figure 2. The value of BOD water quality tends to be fluctuating and the difference between the concentration of BOD in upstream and downstream is affected by sampling condition. When it is not raining, the difference of concentration between upstream and downstream is not really significant. On the contrary, when it is raining, the concentration of BOD in downstream is higher than the concentration in upstream. In the fourth measurement (January 21st, 2018), the concentration in downstream is higher than upstream since it was heavy rain during the sampling (Table 1). Based on the result of BOD monitoring in agricultural land, the concentration of BOD in downstream will be higher if the sampling is conducted during rain. In the normal condition (not raining), the concentration of BOD in downstream will be higher compared with the concentration in upstream.
Table 1. Conditions of sampling water in agricultural land

| Date   | Time interval (hour) | Rainfall (mm) | Discharge (m³/s) | Note                  |
|--------|----------------------|---------------|------------------|-----------------------|
| 1      | 13 Jan 2018          | 8.100         | 4.820            | 0.308 0.198          |
| 2      | 17 Jan 2018          | 15.200        | 5.420            | 0.375 0.264          |
| 3      | 20 Jan 2018          | 1.800         | 4.913            | 0.298 0.137          |
| 4      | 21 Jan 2018          | 1.833         | 4.980            | 0.379 0.320          |
| 5      | 10 Feb 2018          | 20.533        | 2.490            | 0.306 0.161          |
| 6      | 04 Mar 2018          | 9.517         | 3.020            | 0.302 0.124          |

Source: Data observation, 2018

The relation between variables is analyzed statistically. There are three tested variables: the interval \((X_1)\), the thickness of the rainfall \((X_2)\), and the discharge \((X_3)\) (Table 2). Test F is used to know the relation between variables simultaneously, whereas test T is used to know the relation between a certain variable and water quality. Based on the result of test F, the tested variable simultaneously affected water quality, with the value of R square as big as 0.942. Based on the relationship between each variable and BOD water quality in natural land, discharge is the variable that affects water quality. Data distribution of each variable will be analyzed by Scatter Plot.

Table 2. Statistical test result (SPSS) water quality of BOD in agricultural land

|                | \(X_1\) | \(X_2\) | \(X_3\) | Table   |
|----------------|---------|---------|---------|---------|
| F test         | 10.814  |         | 9.280   |         |
| Result         | accepted|         |         |         |
| T test         | -0.403  | -1.588  | 5.273   | 2.776   |
| Result         | rejected| rejected| accepted|         |
| R Square       |         |         | 0.942   |         |
| Equation       | \(0.810 - 0.160 X_1 - 0.490 X_2 + 21.704 X_3\) |         |         |         |

Source: Data Analysis, 2018

Scatter Plot is used to know the pattern of data distribution, in which the data shows the relation between each variable and water quality. The interval between the last rain and the time of sampling does not give impact to BOD water quality, as well as the thickness of the rain. However, the flow is directly proportional to BOD water quality. The pattern of data distribution in variable \(X_1\) and \(X_2\) is generally irregular (Figure 3a and Figure 3b). The pattern of data distribution that shows the relation between flow and water quality can be seen in Figure 3c. The relation between discharge flow and water quality in upstream is inversely proportional, whereas the relation in downstream is directly proportional. In the upstream, the bigger the flow, the better the BOD water quality. While in downstream, the bigger the flow, the worse the BOD water quality.
Pollution load in agricultural land will be transported to the river when rain falls. The force that transports the pollution load is the runoff. In addition, the characteristic of agricultural land is also affected by the dam. In one segment of water quality monitoring, there is a dam for irrigation so that the flow in downstream is lower and pollutant will be restrained in the dam. When it is raining, the runoff will bring the pollutant from agricultural land to the river. As a result, BOD water quality in downstream most likely is worse than BOD water quality in upstream. Other than that, cultivation activities in agricultural land also affect the amount of pollution load transported to the river. For example, bundle in agricultural land will block the pollution load from entering the river. This condition is in line with the research conducted by [5] that says that good practice of cultivation could minimize pollution in agricultural land.

4. Conclusions
NPS pollution load is temporally fluctuating. The biggest pollution load from agricultural land is when it is raining. In normal condition, the amount of pollution load is minimum. Runoff plays a role as the main media that transports the pollution load to the river, the correlation is 0.85. The relation between the concentration of BOD (Y), the variables from rainfall (X₁, X₂), and the discharge (X₃) is formulated as follow \( Y = 0.810 - 0.160 X₁ - 0.490 X₂ + 21.704 X₃ \). The formula can be used for estimate NPS pollution load in Code River or area with the same characteristic.

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