Environmental and Social Approach for Controlling Water Pollution in Krukut River, DKI Jakarta

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Abstract. Jakarta, as a prominent urban area, has limitations of freshwater sources. Krukut River is one of the rivers used as a source of clean water in Jakarta. However, only the upper horizons of the river are utilized. This research aimed to understand the environmental and social aspects that have the potential to maintain Krukut River water quality. DKI Jakarta Environmental Agency in 2018 asserted that the BOD parameter value of Krukut River has increased along from upstream (4.16 mg/l) to downstream (11.57 mg/l) and exceeded the standards of raw water quality set by the government. By conducting a literature review, this research outlined the essential points of the environmental and social aspects that may be the basis of concept regarding the water quality improvement of the Krukut River. This research also calculate the BOD loads from population in Krukut River catchment area as one of the factors potentially contribute to river pollution. The information obtained from this research was expected to be the cornerstone in analyzing river pollution control.

Keywords: Krukut River, BOD, social approach, environmental approach

1. Introduction
Water is a vital component that sustains the life system. Even though water is classified as a renewable energy source, maintaining water availability (both in quality and quantity) is another challenge. Water crisis may happen due to an unbalance water cycle. This issue is essential considering the human needs are more dependent on the use of freshwater, which is only 3% of the total water on earth (where 85% of the freshwater in the form of the glacier which cannot be used directly by humans [1]. There were two types of freshwater that can be utilized by humans, groundwater and surface water [2]. Groundwater usually has better quality compared to surface water because it did not expose directly from the pollutant. However, groundwater is not sustainable to be used in the long term, because it harms the environment, such as land subsidence [3,4]. Surface water also has an issue. It more susceptible to pollution because it is directly related to human activities. [5].

As time goes by, the consumption of freshwater continues to increase, and the limitations of freshwater often create a water crisis [6]. Jakarta, as the Capital State of Indonesia, has 10,374,200 residents who use groundwater and surface water as their primary water source [7]. Jakarta is facing the adverse environmental effects of excessive use of groundwater as well. The high use of

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groundwater as a source of water is one of the causes of land subsidence in Jakarta [3]. For surface water conditions in Jakarta, although Jakarta is crossed by 13 rivers, most of the water quality of the river in Jakarta does not meet the requirements for use as raw water for drinking water. Jakarta still relies on raw water sources from outside the city. More than 50% of Jakarta’s raw water came from outside the city. One of the Jakarta’s raw water source is from the Jatiluhur Reservoir, West Java [8].

DKI Jakarta Environmental Agency stated more than 50% of rivers in Jakarta already categorize as heavily polluted [9]. Krukut river is one of the rivers in Jakarta that still can be used as raw water for drinking water sources [10], [11]. However, only the upstream segment is used as a raw water source. Based on data from DKI Jakarta Environmental Agency [12], it can be seen in figure 1 dissolved oxygen values trends decreases towards the downstream. The location of the monitoring point can be seen more clearly in the Methods section, figure 1.

![Krukut River Dissolved Oxygen Values](image)

**Figure 1.** Krukut River Dissolved Oxygen Values.

Based on dissolved oxygen value, Krukut River quality is diminishing from 2016 to 2018. Each year show the condition of the Krukut river also declined from upstream to downstream. BOD parameter of Krukut River in 2018 has progressed along from upstream (4.16 mg/l) to downstream (11.57 mg/l) and surpassed the standards of raw water quality set by the government (Government Regulation No.82 of 2001, raw water for drinking water standard). The declined water quality of the Krukut River became the main issue in this paper. Therefore, this paper has an objective to reviewing literature and understand the environmental and social aspects that have the potential to maintain Krukut River water quality.

2. Methods
This study aims to understand the environmental and social aspects that have the potential to maintain Krukut River water quality. This paper conducted a literature study that aims to be able to identify kinds of literature related to the purpose of this study. Literature study conducted from the scientific site, including Google Scholar, Scopus, Springer, and so forth. Literature search was focused on social aspects and environmental aspects related to river water quality.

This study focused on the Krukut River in Jakarta area. The monitoring points discussed in this study are based on the sampling station used by DKI Jakarta Environmental Agency to monitor annual water quality. The location of the monitoring point can be seen in figure 2.
In the environmental aspect section, this paper will breakdown the pollutant load from. The formula can be seen at equation 1. This formula stated in Regulation of The Minister of Environment Number 1 of 2010 (regarding procedures for controlling water pollution). The emission factor used in the calculation is 40 g/person/day from IPCC GL 2006, BOD emission factor for domestic wastewater [13]. The population density data used to calculate the population in the catchment area is sourced from districts report in 2018 issued by Central Bureau of Statistics.

\[ \text{Emission} = \text{Emission Factor} \times \text{Population Density} \times \text{Total Area} \]  

3. A Review of Aspect Affecting River Water Quality
Review of various aspects affecting water quality shown at the following. Overview from environmental and social aspects will help to describe the problem of water quality more [14]. Bartram and Balance categorizing four natural processes which are affecting the river water quality. The processes are a hydrological process, physical process, chemical process, and biological process [15]. Social aspects and environmental aspects influence on water quality through these four processes. In detail, the list of the processes can be seen in table 1.
Water quality varies in different seasons. Wet season will have better water quality compared to the dry season [19]. The reason is that rainfall runoff can change the water quality due to many land use from the catchment area. Agriculture runoff is the primary pollutant in several regions [20]. However, Krukut River area is located in cities. So agriculture is not the primary pollutant source that has the potential to pollute the river. Landuse types still need to be estimated, due to the presence of green open spaces in the catchment area of the Krukut River. Camara et al. stated if knowing the type of land use in an area, the type of pollutant that has the potential to enter the river can be identified [21]. For example, in land use for residential, nutrient compounds, suspended solids, and pathogens will dominate. Whereas in industrial areas, heavy metals such as hydrocarbons may appear more. Other environmental factors that influence water conditions are the topography of the river catchment area [22].

Based on the DKI Jakarta Regional Regulation Number 1 of 2014 (regarding plan details and zonation regulations), Central Jakarta and South Jakarta areas are dominated by residential areas. Therefore, the estimation of pollutant loads from the population in the Krukut River catchment area is calculated. The parameter used to calculate the pollutant loads is the BOD parameter. BOD loads from the area of the villages (which is potentially can affect each monitoring point) and the DO values of each monitoring point can be seen in table 2.

### Table 1. Process affecting river water quality [15].

| Process type     | Parameters                        | Major process within water body                  |
|------------------|-----------------------------------|--------------------------------------------------|
| Hydrological     | Flow, flow direction, velocity,   | Dilution, evaporation, suspension, and settling.  |
|                  | depth, water level.               |                                                  |
| Physical         | Temperature, TDS, TSS, turbidity, | Gas exchange with atmosphere, volatilization,    |
|                  | etc.                              | adsorption, heating, and cooling.                |
| Chemical         | pH, BOD, DO, COD, etc.            | Photodegradation, acid-base reaction, redox      |
|                  |                                   | reactions, dissolution of particles, precipitation of minerals. |
| Biological       | E. coli, coliform bacteria, etc.  | bio accumulation and decomposition of organic    |
|                  |                                   | matter                                           |

### 4. Environmental Aspects

Atmospheric deposition is one of the aspects affecting water quality [16]. Rainfall can be an input to the river as a point source (from an urban drainage system) or as a nonpoint source (runoff) [17]. High rainfall intensity influences hydrological processes in the River. River flow will have significant input [18]. Water quality varies in different seasons. Wet season will have better water quality effects compared to the dry season. The distinction is related to the water quality that is very influenced by the river streamflow. During the wet season, rainwater can dilute the pollutants in the river. The dilution may lead to the condition of better water quality compared to the dry season [19].

The process type is flow, temperature, DO, BOD, COD, etc. The reason is that rainfall runoff can change the water quality due to many land use from the catchment area. Agricultural runoff is the primary pollutant in several regions [20]. However, Krukut River area is located in cities. So agriculture is not the primary pollutant source that has the potential to pollute the river. Landuse types still need to be estimated, due to the presence of green open spaces in the catchment area of the Krukut River. Camara et al. stated if knowing the type of land use in an area, the type of pollutant that has the potential to enter the river can be identified [21]. For example, in land use for residential, nutrient compounds, suspended solids, and pathogens will dominate. Whereas in industrial areas, heavy metals such as hydrocarbons may appear more. Other environmental factors that influence water conditions are the topography of the river catchment area [22].

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### Table 2. Krukut River DO Values and BOD Load Estimation [12].

| Monitoring Point | Villages in Catchment Area | Population in Catchment Area (Km²) | BOD Load Estimation (Kg/day) | Total BOD Load Estimation (Kg/day) | DO (mg/L) | 2016 | 2017 | 2018 |
|------------------|---------------------------|------------------------------------|------------------------------|-----------------------------------|-----------|------|------|------|
| 1                | Jagakarsa                 | 29,071                             | 11,628                       | 26,060                            | 7.4       | 3.1  | 3    |
|                  | Ciganjur                  | 26,027                             | 10,411                       |                                   |           |      |      |      |
|                  | Cipedak                   | 10,051                             | 4,021                        |                                   |           |      |      |      |
| 2                | Kebagusan                 | 51,221                             | 20,488                       | 81,267                            | 6.5       | 3.36 | 3.11 |
|                  | Cilandak Timur            | 31,418                             | 12,567                       |                                   |           |      |      |      |
|                  | Ragunan                   | 41,919                             | 16,767                       |                                   |           |      |      |      |
|                  | Pasar Minggu              | 1,224                              | 489.62                       |                                   |           |      |      |      |
|                  | Jati Padang               | 41,621                             | 16,648.34                    |                                   |           |      |      |      |
From table 3, it can be seen that monitoring point 1 has the potential to receive the influence of pollutant load from 3 villages with a total estimated 26,060 kg/day BOD loads. Monitoring point 2 has the potential to receive an additional influence of 81,267 kg/day of BOD loads. Monitoring point 3 is not only influenced by the pollutant loads from the previous point, it is also potentially influenced by 90,050 kg/day BOD loads. Monitoring point 4 which is located at downstream receives a potential load from the previous point and 25,651 kg/day BOD loads. The tendency for a decrease in DO quality is related to BOD loads which are increasingly getting downstream. BOD can be used to represent the amount of organic pollutants [23], [24]. The high level of organic pollutants that enter the river can create a deoxygenation reaction and affected the DO in the water body [24].

5. Social Aspects
The population within the catchment area is a factor that affects the water quality of a river. Increasing population or population density in an area is followed by an increase in waste produced [25], [26]. Luo et al. stated that population density is one of the main factors affecting the river systems [27]. Negative impact may have happened in a condition when the waste and wastewater not appropriately managed [19]. In other words, we could say the level of availability of proper sanitation in the community is also one of the factors that affect water quality in rivers. Proper sanitation is the sanitation facility that has met the health requirements [28]. Difficult access to proper sanitation is more often experienced by people who have financial limitations, or can also be referred to low-income community households [29]. Based on the 2018 Indonesian welfare Indicators report released by BPS-Statistics Indonesia, 85.16% of low-income community households in Jakarta already have access to proper sanitation [28]. Increasing the percentage of proper sanitation availability to the community can potentially reduce the level of pollution in the Krukut River.

Community participation is another social factor that can be used as a key point to control river pollution [30]. Participation can be divided into two types based on the level of volunteerism; Free participation (when the community voluntarily wants to be involved in participating activities) and...
Forced participation (Involvement in participation due to coercion) [31]. The use of wastewater treatment technology can be (i.e. septic tank and wastewater treatment plant) counted as community free participation. Specifically it is a type of induced participation (when an individual receiving encouragement through government programs or persuasion from institution thereby increasing their participation). In addition to participation related to wastewater treatment, there is also community participation in waste management such as implementation of 3R (reduce, reuse, recycle). Implementation of 3R can help to controlled river pollution by reducing the amount of organic waste that has potential to pollute the rivers and affecting the river water quality [32]. Community participation is affected by the level of awareness and knowledge of the community itself. The low level of awareness and knowledge of the community regarding pollution will make it difficult to control the pollution at the river [33].

6. Conclusion
This study identified several factors from environmental and social aspects that affect river water quality based on a literature review. Environmental aspects such as atmospheric parameter dan land use must be taken into account when planning the water quality improvement of Krukut River. From the estimated input BOD loads, the highest BOD loads are from the vilages located between station 3 and station 2, which is 90,050 kg. Whereas from the social aspects, the population in the catchment area became the central factor influencing river water quality since it corresponds to the waste and wastewater produced. The sanitation level and the use of wastewater treatment technology in the community is also a crucial factor in controlling river pollution. This information can be used for analyzing the river pollution control and planning materials to improve the water quality of the Krukut River.

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