Water quality study of Sunter River in Jakarta, Indonesia

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Abstract. Sunter River flows in the city of Jakarta with the designation of river water for agricultural purposes, and can be utilized for urban business and hydroelectric power industry. This study aims to determine the Sunter River water quality based on physical and chemical parameters. Water sampling was conducted 2 times which done in April and May with 5 sampling stations for measuring. The samples was analayzed in the laboratory according SNI methods for parameters BOD, COD, PO₄³⁻, NO₃, Oil & Grease and Detergents. The quality status of Sunter River is determined by the Pollutant Index method. The results show that the water quality of Sunter River is influenced by organic parameter as dominant pollutant with COD concentration ranging from 48 mg/l – 182.4 mg/l and BOD concentration ranging from 14.69 mg/L – 98.91 mg/L. The Pollution Index calculation results show that the water quality status of Sunter River is moderate polluted with IP 6.47. The source of pollutants generally comes from the urban drainage channels, tributaries, and slaughtering industry. The results of this study expected to be use by the government to improve the water quality of Sunter River for better environment.

Keywords: water quality, pollution parameters, Sunter River, pollution index

1. Introduction
Rivers have been utilized by mankind for thousands of years to the extent that few of them are now in their natural condition [1]. The increase of human population and activities give impacts to the water quality. Although some water pollution may occur naturally, most water pollutants are the result of human activities [2]. Much of water pollution results from human activities such as agriculture, mining, manufacturing industries and poor management of urban waste [3]. Industrialization and urbanization can threaten river ecosystems by altering land use and generating waste, resulting in sustained problems [4]. Water quality degradation is one of the most serious of all environmental problems because it can affect human health and economic activities as well as biotic communities [5].

The Sunter River is one of 13 river rivers in Jakarta with main stream along 37 km and river basin (watershed) of 73.18 km² [6]. The river’s upstream is located in Cimpacun Village, Depok City and downstream in Jakarta Bay, Tanjung Priok, North Jakarta. Based on [7] the Sunter River water designation is Class D, which is water that can be used for agricultural purposes, and can be utilized for urban enterprises, hydroelectric generating industries [7]. The Sunter River basin is very densely populated, and floods are frequent.

Based on description above, this study was conducted to to assess the quality of the Sunter River water by identify the type of pollutants entering the river and their impacts. The quality status of Sunter water river can be used to assess the water quality improvement program and might be considered for water resources management.
2. Research Method

2.1. Study Area and Sampling Stations
Sunter River under study has length of 10.4 km and located in the middle and downstream of the main river, which flows from East Jakarta to North Jakarta. To analyze the river quality, 5 sampling stations were determined for measuring. Sampling is done 2 times in April as rainy season and May as dry season. Samples were taken using Grab Sampling method (instantaneous example). Water sampling is done in the middle of the bridge above the river with bottled water sampler made of polyethylene plastic tied with rope. The water samples that have been taken are inserted into a 2L-sized plastic oxygen stored in a refrigerated foam box and later stored in the laboratory for analysis. The coordinates and elevation of the sampling point can be seen in Table 1 while Map of sampling location and Sunter River catchment area can be seen in Figure 1.

| Point | Location                                                                 | Coordinate       | Elevation (m) | Distance (m) |
|-------|--------------------------------------------------------------------------|------------------|---------------|--------------|
| 1     | Jl. I Gusti Ngurah Rai No.37, Klender, Duren Sawit, Kota Jakarta Timur   | 106°53'44.83"    | 6°12'48.37"   | 11 m         | 0            |
| 2     | Jl. Jatinegara Kaum No.29, Jatinegara Kaum, Pulo Gadung, Kota Jakarta Timur | 106°53'51.50"    | 6°12'9.95"    | 11 m         | 1.428        |
| 3     | Jl. Palad, Pulo Gadung, Kota Jakarta Timur                                | 106°54'18.60"    | 6°11'11.01"   | 6 m          | 3.915        |
| 4     | Jl. Perintis Kemerdekaan No.65, Pulo Gadung, Jakarta Timur               | 106°53'50.47"    | 6°10'41.66"   | 6 m          | 5.460        |
| 5     | Jl. Yos Sudarso, Klp. Gading Barat, Kota Jakarta Utara                   | 106°53'26.34"    | 6°8'44.66"    | 5 m          | 10.315       |

Figure 1. Map of sampling location and Sunter River Basin.
2.2. Laboratory Analysis

River water samples are analyzed in the laboratory with the parameters were TDS, BOD, DO, COD, PO₄³⁻, NO₃⁻, Grease Oil and Detergent. Standard analytical procedures were used in the determination of selected physical and chemical water quality parameters of the sample. Parameters analyzed and the method of analysis of the sample refers to the Indonesian National Standard which can be seen in Table 2. Results from the analysis of river pollutant parameters are then compared with river water quality standard in DKI Jakarta [7].

Table 2. Laboratorium method for surface water analysis.

| No. | Parameter                  | Unit  | Method                |
|-----|----------------------------|-------|-----------------------|
| A   | Total Dissolved Solid (TDS) | mg/L  | SNI. 06-6989.27-2005  |
| 1   | Temperature                | °C    | SNI. 06-6989.23-2004  |
| B   | Nitrate (NO₃⁻)             | mg/L  | SNI. 6989.74:2009     |
| 3   | pH                         | -     | SNI. 06-6989.11-2004  |
| 4   | Phosphat (PO₄³⁻)           | mg/L  | SNI. 06-6989.31-2005  |
| 5   | Grease and Oil             | mg/L  | SNI. 06-6989.10-2004  |
| 6   | DO                         | mg/L  | SNI. 06-6989.14-2004  |
| 7   | BOD                        | mg/L  | SNI. 06-2503-1991     |
| 8   | COD                        | mg/L  | SNI. 06-6989.2-2004   |
| 9   | Detergent (MBAS)           | mg/L  | SNI. 06-6989.51-2005  |

2.3. Pollution Index

The results of laboratorium analyses were used to calculate the water quality status of the Sunter River using the pollutant index method. The Pollution Index (IP) is used to determine the level of pollution relative to the permitted water quality parameters [6]. The Pollution Index is determined for a designation, then it can be developed for some designation for all parts of the water body or part of a river. The equation for calculating the pollutant index value is as follows. The calculation results from equation below then matched to the scale in Table 3 to determine the quality status of Sunter River.

\[
Pl_j = \left\{ \left( \frac{C_i}{L_i} \right)^2 M + \left( \frac{C_i}{L_i} \right)^2 R \right\}^{1/2}
\]

Where
- \( C_i \) = Observed concentration of i parameter
- \( L_i \) = Permissible limit of i parameter
- \( M \) = Maximum value of \((C_i/L_i)\)
- \( R \) = Average value of \((C_i/L_i)\)

Table 3. Evaluation of Pollution Index Value.

| No | Pollution Index Value | Water Criteria Status         |
|----|-----------------------|-------------------------------|
| 1  | 0 < IP < 1.0          | Meets Quality Standards (Good)|
| 2  | 1 < IP < 5.0          | Low Polluted                  |
| 3  | 5 < IP < 10           | Moderate Polluted             |
| 4  | IP > 10               | Severe Polluted               |
3. Results and Discussion

3.1. Sunter River Water Quality

Table 4. Sunter River water quality.

| Parameter                | Unit | WQS | 1   | 2   | 3   | 4   | 5   |
|--------------------------|------|-----|-----|-----|-----|-----|-----|
| **Physical**             |      |     |     |     |     |     |     |
| Air Temperature          | °C   | 29  | 30  | 30  | 31  | 31  | 32  |
| Water Temperature        | °C   | 28.8| 28.1| 29  | 29.2| 30.2| 30.1|
| Total Dissolved Solid    | mg/L | 200 | 305 | 316 | 303 | 318 | 306 |
| Conductivity             | μmhos/cm | 1000 | 606 | 631 | 603 | 633 | 613 |
| **Anorganic Chemical**   |      |     |     |     |     |     |     |
| pH                       | mg/L | 6 – 8.5 | 7.4 | 7.16 | 7.27 | 7.25 | 7.34 | 7.31 | 7.24 | 7.32 | 7.57 | 7.35 |
| BOD (5 day 20°C)         | mg/L | 20 | 98.91 | 31.05 | 79.9 | 14.69 | 76.13 | 27.91 | 69.5 | 33.66 | 86.63 | 36.46 |
| COD                      | mg/L | 30 | 182.4 | 64 | 154 | 70.4 | 134 | 73.6 | 134 | 54.4 | 144 | 48 |
| Dissolved Oxygen (PO₄)   | mg/L | >3 | 5.33 | 2.30 | 6.10 | 4.50 | 5.60 | 3.90 | 4.20 | 4.30 | 2.77 | 3.03 |
| Nitrate (NO₃)            | mg/L | 0.5 | 5.43 | 8.36 | 12.27 | 7.05 | 3.59 | 4.74 | 13.57 | 5.62 | 15.42 | 5.30 |
| **Organic Chemical**     |      |     |     |     |     |     |     |     |
| Oil and Grease           | mg/L | 1** | 1.324 | 0.145 | 0.283 | 0.435 | 0.670 | 1.013 | 0.781 | 1.166 | 2.100 | 1.422 |
| Detergent                | mg/L | 0.5 | 8.15 | 2.31 | 8.53 | 6.20 | 6.50 | 3.10 | 2.34 | 1.51 | 7.72 | 5.96 |

*) Class B Water Standard **) Class C Water Standard

WQS = Water Quality Standard (Decree of the Governor of DKI Jakarta Number 582 of 1995)

The results of laboratory analysis showed that anorganic chemical parameters, such as BOD₃, COD, and Phosphate have far exceeded the quality standard of Decree of akarta Governor Number 582 of 1995 for river water of Class D while the physical parameters such as water temperature and water conductivity meet the quality standard.

The highest BOD₃ value was recorded during rainy season (April) with concentration of 98.91 mg/l at Point 1. The mean BOD₃ concentration during dry season (May) was 28.75 mg/L. The BOD₃ value is directly proportional to the COD value, with COD always greater than BOD₃. The concentration of COD in Sunter River were 48 mg/L - 182.4 mg/L in all season. The high concentrations of BOD₃ and COD in Sunter River indicates organic waste as the dominant pollutant. Organic waste in Sunter River one of them comes from residential area that most likely directly dispose grey water into the river. COD concentrations generally indicate that levels of pollution in water bodies are high [8].

In the rainy season (April), Dissolved Oxygen (DO) of Sunter River were 2.77 mg/L - 6.10 mg/L whereas in dry season, DO values range from 2.30 mg/L to 4.50 mg/L. Overall the DO content in Sunter River still meets the quality standard (> 3 mg/L).

3.2. Sunter River Quality Status

The quality status of Sunter River water is calculated based on the results of laboratory analysis of Sunter River water. Determination of status of water quality using method of pollution index (IP) attached in Decree of Environment Minister Indonesia Number 115 Year 2003. Result of calculation status of water quality of Sunter River period of April, May, and July can be seen in following table.
Table 5. Pollution index of Sunter River at every point.

| Point | Location                        | Pollution Index | Average | Status         |
|-------|---------------------------------|-----------------|---------|----------------|
| 1     | I Gusti Ngurah Rai              | 5.96            | 5.41    | 5.69           |
| 2     | Jl Jatinegara Kaum              | 6.91            | 5.38    | 6.15           |
| 3     | Jl Palad, Pulo Gadung           | 5.25            | 4.50    | 4.88           |
| 4     | JL Perintis Kemerdekaan         | 9.18            | 4.70    | 6.94           |
| 5     | Jl. Yos Sudarso, Kelapa Gading  | 12.44           | 5.01    | 8.72           |

The Pollution Index (PI) result shows that the average status of the Sunter River is moderate polluted with average PI of all point 6.47. The calculation results may change if the water quality parameter under study increases. The Advantages of PI method is the result obtained determined based on the unit data and the water quality status at each point can be determined. However, the lack of using this PI method is the result obtained less sensitive because it depends on the number of parameters studied.

Water quality status obtained is the result of instantaneous measurement in accordance with the measurement water flow for 2 months. The discharge of water entering the Sunter River can affect the water quality and the Pollution Index. The results of calculations with the Pollution Index may change if the water quality parameters studied increase. Determination of water quality is important to assess the state of the watershed and to make the management decisions necessary to control current and future pollution of water bodies [9].

4. Conclusion
The Sunter River water quality parameters have exceeded the quality standards for BOD, COD, PO43-, TDS, and (detergent) surfactant anionic parameters. The dominant pollutants entering the Sunter River are organic waste that may come from residential, traditional market, and chicken slaughtering house. The water quality status of the Sunter River during 2 months of monitoring was in the medium polluted category with an average IP of 6.47. The water quality status of the Sunter River in May (dry season) is better than April (rainy season). Therefore, this research can be used as a guideline for the government in improving the quality of River Sunter’s water.
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