Study of pollution effect on water quality of Grogol River, DKI Jakarta

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Abstract. A study has been conducted to identify the incoming pollutants and assess the water quality in Grogol River, DKI Jakarta, Indonesia, which has a length of 13.35 km and consists of two segments. The water quality assessment is determined by pollution index method, referring to Minister of Environment Decree No. 15/2013 on The Guidelines of Water Quality Status. The samples were taken both in rainy and dry seasons at 7 sampling points. Based on the analyses of 10 key parameters and the calculation of pollution index value, it can be concluded that Grogol River is low polluted in rainy season and moderate polluted in dry season. The information obtained from this research can be used for decision making to improve the water quality of Grogol River.

Keywords: Grogol River, pollutant index, water quality assessment

1. Introduction

Rivers in underdeveloped and developing countries are widely used as waste disposal sites for domestic and industrial waste. The waste contains various types of contaminants that contribute to the poor quality of river water [1].

Grogol River is one of the rivers that flow past DKI Jakarta (capital city of Indonesia). The upstream of this river is located in the area of Pancoran Mas, Depok City, West Java Province. The focus of the research conducted at the downstream segment located in DKI Jakarta Province, more precisely in South Jakarta City, Central Jakarta City and West Jakarta City.

Based on the sources, there are two kinds of pollutants defiling the river, i.e., point source and non-point source. Point source pollution is water contamination that comes from a single place, usually like a pipe. Non-point source pollution is the scouring and leaching caused by rainfall-runoff processes, dissolved or solid pollutants on the ground and in the soil entering rivers, lakes, reservoirs, and the ocean, tainting the aquatic environment [2].

Based on the above description, this research needs to be done to identify pollutants entering the Grogol River and to see the quality status of the grogol river so that it can be used as a reference to improve the water quality of Grogol River.

2. Research Method

The research area of Grogol River is 13.35 km. The samplings were done at 7 points of main river point and 2 point from point source of Grogol River which are a tributary and a drainage. Sampling was conducted during the rainy and dry seasons (Table 1). The sampling point is determined by the accessibility of the location and the pollutant input location.
Table 1. Coordinates of the sampling locations of Grogol River.

| Sampling Points | Types       | Locations                  | Coordinates                  |
|-----------------|-------------|----------------------------|------------------------------|
| 1               | Main Point  | Jl. Kyai Moh. Syaffi Hadzami | 6°14'44.3"S 106°47'16.7"E    |
| 2               | Main Point  | Jl.Hang Lekir I             | 6°13'45.3"S 106°47'45.0"E    |
| 3               | Main Point  | Jl. Patal Senayan           | 6°13'7"S 106°47'49"E         |
| 4               | Main Point  | Jl. Palmerah Barat          | 6°12'28.2"S 106°49'32.6"E    |
| 5               | Main Point  | Jl. Anggrek Rosalianna      | 6°11'42.9"S 106°47'37.2"E    |
| 6               | Main Point  | Jl. Letjen S. Parman (in front of CP Mall) | 6°10'29.6"S 106°47'27.9"E |
| 7               | Main Point  | Jl. Letjen S. Parman (in front of Ciputra Mall) | 6°10'04.5"S 106°47'16.5"E |

The methods used to analyze ten key parameters of Grogol River water samples are listed in Table 2. Two quality standards were used as references, i.e., Governor of DKI Jakarta Decree (KEPGUB) No. 582/1995 and Government Regulation (PP) No. 82/2001. The latter is used as the secondary guide if the parameter is not registered in the Governor Decree.

Table 2. Measurement methods of water quality parameters.

| No. | Water Quality Parameters | Units | Analytical Methods | Standard Quality Types |
|-----|--------------------------|-------|--------------------|------------------------|
| A   | Physical Parameters      |       |                    |                        |
| 1   | Total Dissolved Solids (TDS) | mg/L  | SNI 06-6989.27-2005 | KEPGUB DKI Class D     |
| 2   | Conductivity             | μmhos/cm | SNI 06-6989.11-2004 | KEPGUB DKI Class D     |
| 3   | Temperature              | °C    | SNI 06-6989.23-2004 | KEPGUB DKI Class D     |
| B   | Chemical Parameters      |       |                    |                        |
| 4   | Nitrate (NO₃)            | mg/L  | SNI 6989.74:2009   | PP No. 82/2012 Class 4 |
| 5   | pH                       | -     | SNI 06-6989.11-2004 | KEPGUB DKI Class D     |
| 6   | Phospat (PO₄)            | mg/L  | APHA Method 4500-P | KEPGUB DKI Class D     |
| 7   | Grease and Oil           | mg/L  | SNI 06-6989.10-2004 | PP No. 82/2001 Class 3 |
| 8   | Dissolved Oxygen (DO)    | mg/L  | SNI 06-6989.14-2004 | KEPGUB DKI Class D     |
| 9   | Biochemical Oxygen Demand (BOD) | mg/L | SNI 06-2503-1991   | KEPGUB DKI Class D     |
| 10  | Chemical Oxygen Demand (COD) | mg/L | SNI 06-6989.2-2004 | KEPGUB DKI Class D     |
| 11  | Metylene Blue Active Substance (detergent) | mg/L | SNI 06-6989.51-2005 | KEPGUB DKI Class D     |

The pollution index (PI) method was used to calculate the quality status of the river. As an index-based approach, this method is built on two quality indexes. The first is the average index (Iₐ) that shows the average pollution level of all parameters in one observation, while the second is the maximum index...
(IM) that indicates one type of dominant parameters causing a decrease in water quality at one observation [3]. Pollution index are calculated using equation 1.

\[
P_I = \sqrt{\left(\frac{C_i}{L_{ij}}\right)^2_M + \left(\frac{C_i}{L_{ij}}\right)^2_R}
\]

Where,  
- \( C_i \): Observed concentration of i parameter  
- \( L_{ij} \): Permissible limit of i parameter  
- \( M \): Maximum value of \( C_i/L_{ij} \)  
- \( R \): average value of \( C_i/L_{ij} \)

The categories of water quality assessment based on pollution index value are as follows [4]:
1) Meet quality standards: \( IP \leq 1 \)  
2) Low Polluted: \( 1 < IP \leq 5 \)  
3) Moderately Polluted: \( 5 < IP \leq 10 \)  
4) Heavily Polluted: \( IP > 10 \)

3. Results and Discussion

3.1. Results of water quality measurement of Grogol River

The result of two water quality measurements of Grogol River, i.e., in the rainy season (RS) and the dry season (DS) shown at Table 3.

Water temperature of Grogol River is ranging from 28 °C - 30 °C. It can be considered in good condition because do not have much differences compared to ambient temperature which is ranging from 27 °C - 30 °C. Water Temperature is basically important because it give effects to aquatic organism [5].

The result of TDS and conductivity of Grogol River also can be considered in good condition. TDS value ranging from 139 mg/L – 245 mg/L (RS) and 241 mg/L – 287 mg/L (DS). Conductivity value ranging from 278 µhos/cm – 490 µhos/cm (RS) and 481 µhos/cm – 575 µhos/cm (DS). Governor of DKI Jakarta Decree No. 582/1995 for Class D requires TDS <200 mg/L and conductivity <1000 µhos/cm and the result from 7 sample points both rainy season and dry season still not exceed the standard.

pH value of Grogol River showed no significant difference between each sampling point (both rainy season and dry season) and the value still fulfill the water quality standard from Governor of DKI Jakarta Decree No. 582/1995 for Class D. NO₃ value of Grogol River also shown no significant difference between each sampling point (both rainy season and dry season). NO₃ concentration is ranging from 0 mg/L – 0.02 mg/L (RS) and 0.01 mg/L – 0.03 mg/L (DS). Those concentration stil not exceed water quality standard by Government Regulation (PP) No. 82/2001, Class 4.

Dissolved oxygen of Grogol River ranged from 2.2 mg/L – 4.9 mg/L (RS) and 2.23 mg/L -3.35 mg/L (DS). In Rainy Season, 2 sampling point has DO concentration below the standard (>3 mg/L) and increased in dry season to 4 sampling point. Low DO concentration can be caused by the organic materials that pollute the river. Oxygen will be consumed to decompose organic material.

Oil and grease concentration of Grogol River ranging from 0.24 mg/L – 0.78 mg/L (RS) and 0.13 mg/L -0.9 mg/L (DS). Oil which forms a surface film on the river can coat plants and animals reducing oxygenation from the atmosphere above. The film of oil that floats over the water body affects the transmission of light through the water body there by disturbing the process of photosynthesis in the aquatic plants [6]. Governor of DKI Jakarta Decree No. 582/1995 for Class D requires oil and grease <1 mg/L and the result both rainy season and dry season still not exceed the standard.
Table 3. Measurement results of water quality parameters in the rainy season and dry season.

| Parameter                  | Unit | Standard | 1   | 2   | 3   | 4   | 5   | 6   | 7   |
|----------------------------|------|----------|-----|-----|-----|-----|-----|-----|-----|
|                            |      |          | RS  | DS  | RS  | DS  | RS  | DS  | RS  | DS  |
| Physic                     |      |          |     |     |     |     |     |     |     |     |
| Temperature                | °C   | ±3       | 29  | 28  | 29  | 28  | 29  | 29  | 29  | 29  |
| TDS                        | mg/L | 200      | 139 | 241 | 179 | 260 | 191 | 245 | 259 | 238 |
| Conductivity               | μhos/cm | 1000 | 278 | 481 | 358 | 520 | 381 | 489 | 499 | 476 |
| Anorganic Chemical         |      |          |     |     |     |     |     |     |     |     |
| pH                         | 6 - 9|          | 7.01| 7.26| 7.19| 6.50| 6.98| 7.10| 7.04| 7.00|
| DO                         | mg/L | >3       | 3.40| 3.25| 4.90| 2.23| 4.70| 2.30| 3.95| 4.50|
| BODs                       | mg/L | 20       | 26.54| 9.30| 15.81| 26.26| 54.16| 52.64| 41.16| 28.14|
| COD                        | mg/L | 30       | 61.34| 43.2| 68.16| 73.60| 74.98| 72.00| 78.38| 64.80|
| Total Phosphate            | mg/L | 0.5      | 1.18| 3.76| 8.85| 10.45| 6.04| 8.76| 10.05| 6.72|
| NO₃                        | mg/L | 10⁺      | 0.02| 0.01| 0.02| 0.03| 0.00| 0.03| 0.00| 0.02|
| Organic Chemical           |      |          |     |     |     |     |     |     |     |     |
| Oil and Grease             | mg/L | 1**      | 0.79| 0.13| 0.78| 0.43| 0.64| 0.85| 0.37| 0.85|
| Detergent (MBAS)           | mg/L | 0.5      | 1.33| 1.04| 1.06| 2.25| 1.38| 2.50| 1.03| 2.58|

Note:  
* Government Regulation (PP) No. 82/2001, Class 4  
** Governor of DKI Jakarta Decree (KEPGUB) No. 582/1995, Class C
Pollutants that entering the Grogol River are from activities near Grogol River. The pollutants dominated by domestic waste. It is proven from the high concentration of phosphates and detergent parameter. Phosphate ranging from 1.18 mg/L – 10.05 mg/L (RS) and 3.76 mg/L - 13.16 mg/L (DS) and detergent ranging from 1.03 mg/L – 4.23 mg/L (RS) and 1.204 mg/L - 3.90 mg/L (DS). Domestic and industrial wastewater such as from laundry and dry cleaning services release high concentration of phosphates through detergents used into the land and water environment [7].

BOD and COD concentration have a straightforward value. Grogol River BOD concentration ranged from 15.81 mg/L – 54.16 mg/L (RS) and 9.3 mg/L – 52.64 mg/L (DS). COD ranged from 61.34 mg/L – 102.24 mg/L (RS) and 43.2 mg/L – 72 mg/L (DS). In the dry season, almost all parameters have increased concentration (except BOD and COD). The BOD value in rivers often increases during periods of heavy rain and high river flows as organic matter is washed in from the land [8].

3.2. Grogol river quality status by pollution index method

Based on the result of calculation of quality status, Grogol River has more moderate polluted status at its monitoring points (can be seen at Figure 1 and Table 4). Constantly, it appears that the quality status of point 1 is always in low polluted state and points 2 and 4 are constant in moderate polluted conditions. The highest Pollution Index value are at the point 7 in Dry Season in the amount of 5.889 and the lowest PI value are at point 1 in Rainy season in the amount of 2.369.

![Figure 1. The pollution index value of Grogol River.](image)

| Points | Rainy Season | Dry Season | Mean | Quality Status      |
|--------|--------------|------------|------|---------------------|
| 1      | 2.369        | 3.896      | 4.098| Low polluted        |
| 2      | 5.234        | 5.537      | 5.617| Moderate polluted   |
| 3      | 4.702        | 5.310      | 5.108| Moderate polluted   |
| 4      | 5.467        | 4.881      | 5.462| Moderate polluted   |
| 5      | 3.465        | 5.900      | 5.099| Moderate polluted   |
| 6      | 4.203        | 5.861      | 5.375| Moderate polluted   |
| 7      | 3.785        | 5.690      | 5.200| Moderate polluted   |
| Mean   | 4.175        | 5.295      |      |                     |

Table 4. The quality status of Grogol River by pollution index method in RS and DS.
Based on the data listed in tables above, it can be seen that during Rainy season with the pollution index mean value 4.175, Grogol River is polluted and the dry season with the pollution index mean value 5.295, Grogol River is moderate polluted.

4. Conclusion
The primary pollutants of Grogol River are COD, BOD$_5$, phosphate and detergent. Those four parameters almost in all sampling points pass the quality standard both in the rainy and dry season. The pollutant index (IP) value of Grogol River range are 2.369—5.890 from both rainy season and dry season and Grogol River quality status are dominated by moderate polluted status at dry season and dominated by low polluted status at rainy season.

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