Water quality analysis of Saluran Tarum Barat, West Java, based on National Sanitation Foundation-Water Quality Index (NSF-WQI)

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Abstract. The Saluran Tarum Barat, which is 68.74 kilometers long, starts in Klari, Karawang, West Java, and ends in Cawang, East Jakarta. The Saluran Tarum Barat runs alongside human activities and various environmental conditions. The initial part of the Saluran Tarum Barat is surrounded by agricultural activities, the central part by industrial activities, and the final part by infrastructure development activities. Those various activities and environmental conditions may have different effects on the water quality of the Saluran Tarum Barat. The purpose of this research is to ascertain the water quality of the Saluran Tarum Barat based on physical, chemical, and biological parameters determined through the National Sanitation Foundation-Water Quality Index (NSF-WQI) method. The results showed that the water quality is classified in the medium category, with a value range of 55.06–67.92.

Keywords: Water quality analysis, national sanitation foundation-water quality index, Saluran Tarum Barat

1. Introduction
Water is a fundamental natural resource for sustaining living organisms; thus, it is important to maintain its quality. The area of DKI Jakarta has several channels whose main function is as a water catchment area to accommodate flood problems in urban areas [1]. The Saluran Tarum Barat, is one of that channels that starts from Karawang, West Java, and extends across Jakarta. The Saluran Tarum Barat was built to carry out three main functions, namely as an irrigation channel, a power plant, and a raw water source for a drinking water company (Perusahaan Air Minum).

The water quality of the channel is influenced by the various activities that take place around the stream. Water quality at the Saluran Tarum Barat certainly has an effect on the ecological function of the channel in the ecosystem [2]. Allegations of a decrease in the quality of the water in the Saluran Tarum Barat were first made when the water at the end of the channel, in DKI Jakarta, had a cloudy brown appearance. In this area activities related to the construction of the Becakayu toll road are taking place. Similarly, the appearance of the water in the middle of the channel is blackish and smelly, while at the beginning of the channel flow, in Karawang, the dominant activities that can be observed are bathing, doing laundry, and going to the toilet (MCK: Mandi Cuci Kakus).

The assessment of river water quality can be done through the observation of physical, chemical, and biological parameters [3]. The National Sanitation Foundation-Water Quality Index (NSF-WQI)
consists of physical, chemical, and biological parameters for making such an assessment [4]. The physical parameters of water quality are temperature, turbidity, and total solid (TS). The chemical parameters of water quality are pH level, biological oxygen demand (BOD5), dissolved oxygen (DO), and nitrate and phosphate content. The biological parameters are assessed from the fecal coliform content in 100 ml of river water samples [5].

The NSF-WQI method is considered to have an advantage in showing the quality of the water because the physical, chemical, and biological parameters of the water are involved in the calculations using this method. Based on this background, research on the Saluran Tarum Barat was conducted to assess the water through the physical, chemical, and biological parameters in the NSF-WQI calculation method. This study aims to determine the water quality of the Saluran Tarum Barat by employing the NSF-WQI calculation method at the beginning, middle, and end of the channel [6].

2. Experimental

2.1. Location and time of study
The research was conducted at the Saluran Tarum Barat and the Water Laboratory of Perum Jasa Tirta II. The channel is divided into three stations of observation, namely the beginning, middle, and end of the channel, in accordance with the method of purposive sampling. The study was conducted for three months, from March to May 2017, representing the transition period from the rainy season to the dry season.

2.2. Data retrieval
In-situ measurements of the physical and chemical parameters on the Saluran Tarum Barat include temperature, pH, and DO measurements. Ex-situ measurement of the physical, chemical, and biological parameters at the Perum Jasa Tirta II Water Laboratory include turbidity, TS, BOD5, phosphate and nitrate content, and also fecal coliform content. All the tests in the laboratory are based on the IKM Perum Jasa Tirta II, which refers to the Indonesian National Standard (SNI) and the American Public Health Association (APHA). A test to determine the content of coliform fecal bacteria was conducted using the Quanti-Tray method, according to IDEXX Laboratories (table 1).

2.3. NSF-WQI calculation
The data of the parameters that have been observed is, then, determined by NSF-WQI calculation using the formula proposed by Abbasi et al. [5],

\[
WQI = \sum_{i=1}^{n} w_i q_i
\]

Annotation: WQI: Water Quality Index with a magnitude of 0 to 100; q_i: Quality parameters with a value of 0 to 100 (q value); w_i: Unit weighting parameter with value 0–1; n: Number of parameters on NSF calculation–WQI.

The value calculation involves the q value (q_i) obtained by matching the observed or test results in the q value table or curve, then, multiplied by the weighting factor (w_i) of each parameter defined by the NSF-WQI method (table 2).

After the calculations, the results were, then, compared with the water quality classification categories according to the NSF-WQI method (table 3).

To determine the correlation between the quality of the water at an observation station and the surrounding land use, the value of WQI obtained at an observation station was compared with the value obtained at other such stations.
3. Results and discussion

3.1. Environmental conditions of Saluran Tarum Barat

The beginning of the Saluran Tarum Barat is located in Karawang, West Java Province. The surrounding environment at this part of the channel is dominated by agricultural activities and housing. In this section, recreational fishing activities, bathing, doing laundry, and going to the toilet (MCK) activities by residents also take place. The middle of the Saluran Tarum Barat is located in West Cikarang, West Java Province. The surrounding environment in this part of the canal is dominated by industries. The final part of the Saluran Tarum Barat is located in Kramat Jati, East Jakarta. At the end of the channel, construction of the Becakayu toll road is occurring from Bekasi to Kampung Melayu, whose foundation is around the stream of Saluran Tarum Barat.

| Parameter     | Unit      | Tool/method       |
|---------------|-----------|-------------------|
| Temperature   | °C        | Multiparameter Digital |
| Turbidity     | NTU       | Turbidimetry      |
| TS            | mg/L      | Gravimetry        |
| pH            | pH Unit   | Multiparameter Digital |
| DO            | %         | Multiparameter Digital |
| BOD₅          | mg/L      | Winkler Iodide - Azide |
| Phosphate     | mg/L      | Spectrophotometry |
| Nitrate       | mg/L      | Cadmium Reduction |
| Fecal coliform| colony/100 mL sample | IDEXXQuanti-tray |

**Table 2. Weighting factor (w₁)**

| Parameter     | Weighting factor |
|---------------|------------------|
| Temperature   | 0.10             |
| Turbidity     | 0.08             |
| Total Solid   | 0.07             |
| pH            | 0.16             |
| DO            | 0.17             |
| BOD₅          | 0.11             |
| Phosphate     | 0.10             |
| Nitrate       | 0.10             |
| Fecal coliform| 0.16             |

**Table 3. Water Quality Index category**

| Score range | Category   |
|-------------|------------|
| 91–100      | Excellent  |
| 71–90       | Good       |
| 51–70       | Medium     |
| 26–50       | Bad        |
| 0–25        | Very Bad   |
3.2. Condition of west Saluran Tarum Barat based on NSF-WQI parameters

Table 4 shows the results of observations and laboratory tests based on NSF-WQI parameters. The data of nine parameters at each station is presented as the average value ($x$) obtained from the three sampling processes from March to May 2017.

3.3. Temperature

At the beginning of the channel, aquatic plants were found on the side of the channel, which helps regulate the water temperature [7]. A very open water surface was observed at the second station, which allows the water to be directly exposed to a high intensity of sunlight [7]. At the last station, there is a foundation for a toll road on both sides of the channel, which acts as a cover that keeps the water from being exposed directly to the sunlight. In general, tropical waters have temperatures of 25–30 °C; therefore, the temperature values obtained at all three stations are still normal [8].

3.4. Turbidity

Observations at the three stations showed significantly that station 1, which is at the beginning of the channel, has a very low turbidity value compared to the other two stations. This could be caused by the location of station 1, at which there are not many human activities in the surrounding environment. Stations 2 and 3 have relatively high turbidity values ranging from 56.3 to 61.1 NTU. High turbidity values inhibit organisms from living in the waters, because an increase in turbidity of 5 NTU in rivers can inhibit primary productivity by 3–13% [9].

3.5. Total solid (TS)

TS values are closely related to the turbidity value of a body of water. Station 2 has the highest TS content value of the three stations, amounting to 348 mg/L. The presence of industry around station 2 causes the high value of TS and turbidity at that station, because there is a possibility of leakage from the industrial exhaust system [10]. Station 3 also has a high TS value of 301 mg/L, which could be due to the influence of the toll road construction on both sides of the channel.

3.6. pH

At station 1, it is observed that the pH values are the most alkaline of the two other stations. Such a condition can be caused by the high growth of plants around the water that use a lot of CO$_2$ during photosynthesis. This is evidenced by the presence of high-intensity vegetation on the sides of station 1.

### Table 4. Observation table of Saluran Tarum Barat based on parameters in NSF-WQI method from March to May 2017.

| Parameter       | Unit     | Station 1 | Station 2 | Station 3 |
|-----------------|----------|-----------|-----------|-----------|
|                 |          | x q1 w1 q1w1 | x q1 w1 q1w1 | x q1 w1 q1w1 |
| Temperature     | °C       | 27.3      | 93 0.10 9.30 29.0 | 93 0.10 9.30 28.7 | 93 0.10 9.30 |
| Turbidity       | NTU      | 17.3      | 63 0.08 5.04 61.1 | 33 0.08 2.64 56.3 | 37 0.08 2.96 |
| Total Solid     | mg/L     | 59        | 87 0.07 6.09 348 | 53 0.07 3.71 301 | 60 0.07 4.20 |
| pH              | pH unit  | 8.06      | 82 0.16 13.12 7.93 | 86 0.16 13.76 7.90 | 87 0.16 13.92 |
| DO              | %        | 65.43     | 67 0.17 11.39 62.65 | 62 0.17 10.54 70.06 | 75 0.17 12.75 |
| BOD             | mg/L     | 12.6      | 26 0.11 2.86 21 11 | 0.11 1.21 10 | 34 0.11 3.74 |
| Phosfat         | mg/L     | 0.34      | 77 0.10 7.70 3.9 | 18 0.10 1.80 0.25 | 87 0.10 8.70 |
| Nitrate         | mg/L     | 0.13      | 97 0.10 9.70 0.20 | 97 0.10 9.70 1.08 | 96 0.10 9.60 |
| Fecal coliform  | colony/100 mL | 2826 | 12.6 0.11 2.86 21 11 | 0.11 1.21 10 | 34 0.11 3.74 |
| WQI Score       |          | 67.92     | 55.06     | 67.25     |
| Category        |          | Medium    | Medium    | Medium    |
The amount of vegetation is also associated with the alleged presence of agricultural waste in the waters. Berezina states that the normal pH of freshwater water ranges from 6.5 to 8.5 [11]. This shows that the pH of the waters at stations 1, 2 and 3 is still normal for the aquatic biota.

3.7. Dissolved oxygen
Normal water typically has dissolved oxygen content of 80 % or more [12]. This suggests that the Saluran Tarum Barat cannot be classified as healthy water, because the solubility range of oxygen in the channel is 65.43–70.06 %. Station 3 has the highest average dissolved oxygen saturation among the three stations, which is 70.06 % or the closest to 80 %; therefore, it can be said that the dissolved oxygen saturation at station 3 is quite good. The position of the station away from industrial and agricultural activities, as well as sampling time being conducted in the morning, resulting in high oxygen solubility in water, because the temperature is relatively low in the morning.

3.8. Biological oxygen demand (BOD$_5$)
The BOD$_5$ value in water is below 8 mg/L. If waters have a BOD value exceeding that number, then, aquatic biota can be threatened [13]. Station 2 has the highest BOD value, indicating there is higher organic material input at that station than at the other stations. The location of station 2 adjacent to industrial development, as well as the flow of water from the initial direction of the channel carrying the input of the remaining agricultural material, could be the cause of the high value of BOD at station 2.

3.9. Phosphate content
The value of the phosphate content at station 2 can be said to be abnormal, because the normal phosphate content of freshwater waters is below 1.00 mg/L [14]. The station’s environmental condition is also surrounded by industries that can contribute phosphate-containing waste materials to the water. This is due to the phosphate compound that is added to industrial engine coolant water to prevent corrosion, thereby, increasing the phosphate content in water when the cooling water is released outside [15].

3.10. Nitrate content
The normal nitrate content for the water is below 10 mg/L [16]; therefore, the nitrate content at station 3 is still normal despite its high value (1.075 mg/L). Scozzari et al. [17] suggest that domestic waste in urban areas is predominantly high in nitrate compared to other areas. This is in accordance with the location of station 3 at the end of the channel, which is located in the east of DKI Jakarta. The high nitrate content of station 3 is also proportional to the value of fecal coliform content at this station.

3.11. Fecal coliform
The value of fecal coliform content that increases along the flow path of the channel indicates the accumulation of fecal coliform content from the beginning to the end of the channel. That is because it can always be found in MCK activities of each section of the channel. Other activity that may contribute to the presence of fecal coliform content in the water is the poor condition of the septic tank systems of housing residents that may cause fecal coliform content leakage. Fecal coliform bacteria is dangerous if it enters the human body, since it is pathogenic and can cause conditions such as diarrhea, stomach cramps, and intestinal swelling [18].

3.12. Water quality of Saluran Tarum Barat based on NSF-WQI
The WQI value range of the Saluran Tarum Barat from the beginning to the end is 55.06–67.92. The classification of the water quality category of the NSF-WQI indicates that the overall water of the Saluran Tarum Barat is ranked medium (table 4). The initial part of the Saluran Tarum Barat has poor parameter measurements on the pH, BOD$_5$, and fecal coliform parameters. Station 2 has the lowest WQI value due to the presence of many poorly rated parameter measurements at the station, such as turbidity, TS, BOD$_5$, phosphate content, and fecal coliform content. The final part of the Saluran Tarum Barat has
poor parameter measurement results on the turbidity parameter, TS, BOD₅ and fecal coliform with an NSF-WQI value of 67.92.

4. Conclusion
The Saluran Tarum Barat has a medium water quality according to this assessment based on the NSF-WQI method, with a range of 55.06–67.92. Assessment of water quality using other methods or indexes could be carried out to support the results of the present research.

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