Biological water quality of Gajah Wong River, Yogyakarta City, Indonesia

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Abstract. Climate change causing a shift in the dry and rainy seasons, and impacts the availability of water that is getting less. Its change people activity used the river directly thus increasing pollution. As a river management effort, it is necessary to carry out periodic monitoring by public. This study aims to determine the biological water quality of the Gajah Wong river segment Yogyakarta city, Indonesia based on biomonitoring with family biotic index (FBI). The data used are primary data form field data collection. The data collection method used is biomonitoring. The observed parameters were the overall diversity of benthic macroinvertebrates, Water quality follow analysis with family biotic index (FBI). The results showed the stations Gajah Wong 2 (GW2), GW3, and GW8 were of the water quality good, whereas the stations GW1, GW7, and GW6 were of the quality fair fairly. Then the stations GW5 and GW10 were of the water quality fairly poor, the stations GW9 poor very, and finally, station GW4 were of the water quality very poor, this can be seen in the result of the collected organism data, namely the majority is Tubificidae group found 65.30\%. It can be concluded that the Gajah Wong river segmented of Yogyakarta city is polluted.

1. Introduction
A large number of climate changes have been observed on both global and local scales, including long-term changes in the surface temperature, precipitation, wind patterns, radiation, and other extreme weather events, such as droughts, floods, and heatwaves \cite{1, 2}. Extreme weather events including typhoons, storms, and temperature jump mainly result in water events, such as floods and droughts, which may further affect the water quantity and quality \cite{3}. And one of the most affected is river.

The specific effects will vary among different regions and types of water bodies \cite{4}. Van Vliet assessed in 1976 and 2003 on the water quality of Meuse River in western Europe, and the results showed that, compared with reference years, the concentrations of chlorophyll increased by 72.8\% in 1976 and by 16.7\% in 2003 due to decreases in the dilution effect and that the concentrations of nutrients and major elements also increased during the drought periods \cite{5}.

Gajah Wong river is part of Opak watershed located in Special Province Yogyakarta affected indirectly by climate change. Climate change causing a shift in the dry and rainy seasons, and impacts the availability of water that is getting less. Its change people activity used the river directly thus increasing pollution. Currently, the condition of the Gajah Wong river is apprehensive, with increasing pollution. The source of pollution upstream is agriculture and household. Climate change can alter the
water quality and even water ecosystems directly or indirectly through various biochemical processes [6, 7]. Further in the middle of the river is dominated by household, laundry, restaurant, and industrial activities.

The most frequently used community to determine the water quality in the streams is the macroinvertebrates [8]. Many studies on these groups are available [9]. The study of river benthic macroinvertebrates for biological monitoring techniques has been widely reported and described in the literature [5, 9, 10]. Iliopoulou-Georgudaki showed that the use of macroinvertebrates as bioindicators for the assessment of water quality has more advantages than those based on diatoms, fishes, riparian and aquatic vegetation [11]. Benthic macroinvertebrates are often the taxa group of choice for biotic indices in river environments as they are found throughout the length of the river, have limited mobility and a relatively long lifespan. Most interestingly, freshwater macroinvertebrate species vary in their sensitivity to organic pollution [9] and, as a result, their presence or absence can be used to make inferences about pollution loads. Biotic indices are numerical expressions combining a quantitative measure of species diversity with qualitative information on the ecological sensitivity of individual taxa [12].

While the study of macroinvertebrates as an impact indicator can reveal the occurrence of intermittent or unrecorded chemical pollution incidents [9]. Diversity indices are good for indicating physical and toxic pollution which stress most species in a community without encouraging replacement species. He warns that high diversity does indicate good quality water but low diversity may not necessarily indicate low quality. According to our results, low diversity expresses low quality and high diversity expresses good quality. The biotic index and score systems are better for assessing organic pollution and eutrophication but poor for assessing toxic and physical pollution. In Indonesia to determine water quality with several biotic indexes, like FBI, LQI. One of the most common biotic indices in use is the family biotic index (FBI) score system [13].

The effort to improve pollution in the Gajah Wong river is carried out by monitoring water quality. Monitoring of Gajah Wong river at Yogyakarta city, which is carried out by stakeholders only uses a chemical, physical, and microbacteria approach. But there is almost has not been much information on biomonitoring to determine the level of river pollution. Therefore, need to add biological parameters using benthic macroinvertebrate indicators. The purpose of this study to determine the biological water quality of the Gajah Wong river segment Yogyakarta city, Indonesia based on biomonitoring with family biotic index (FBI).

2. Method

2.1 Study area

The study area of this research was Gajah Wong rivers in April 2021. Rivers were located at Yogyakarta City, Indonesia. Near each riverside, there were residential areas. Samples were collected at 10 stations (Table 1). The selection of 10 data collection stations based on several factors. There is access that can be passed to get to the river and representative of the existing land use on the riverbank in Yogyakarta city. And choose a river with a depth of only a maximum of 40 cm, so that it is affordable to put the net.

2.2 Procedures

Sample collection This research was conducted by the transect method. Macroinvertebrate samples were collected by kick net. The net was put on the substrate of the river in opposite direction from the river current. The samples were removed from the net by rubbing off the stones in each plot for 3 minutes. The collection was done at 10 stations of Gajah Wong rivers. The current velocity of the rivers was measured at every plot.
Table 1. Location of six study sites at Gajah Wong rivers, segmented Yogyakarta city, Indonesia.

| No. | Station | Location                  |
|-----|---------|---------------------------|
| 1   | GW1     | Santo Thomas              |
| 2   | GW2     | Fishery Academy Bridge    |
| 3   | GW3     | Balirejo Dam              |
| 4   | GW4     | Gembira Loka Zoo Bridge   |
| 5   | GW5     | Warung Boto Bridge        |
| 6   | GW6     | Umbulharjo Residence      |
| 7   | GW7     | Gajah Wong Educational Park |
| 8   | GW8     | PU Kota Gede Bridge       |
| 9   | GW9     | Tegal Gendu Bridge        |
| 10  | GW10    | Gajah wong Tourism Dam    |

Note: GW = Gajah Wong, the location is used as a place for data collection.

2.3 Data analysis

Family Biotic Index

\[ \text{FBI} = \sum \frac{x_i \times t_i}{n} \] (1)

Where are:

- FBI = Family Biotic Index
- \( x_i \) = the number of individuals belong to family i
- \( t_i \) = score of tolerance of family i
- \( n \) = the total number of collected individuals

After all data deep in the formula above, we can determine water quality based on FBI (Table 2). There are 7 categories with information.

Table 2. Degree of pollution based on Family Biotic Index (FBI).

| Family Biotic Index | Water Quality   | Degree of Organic Pollution           |
|---------------------|-----------------|---------------------------------------|
| 0.00 - 3.75         | Excellent       | Organic pollution unlikely             |
| 3.76-4.25           | Very good       | Possible slight organic pollution      |
| 4.26-5.00           | Good            | Some organic pollution probable        |
| 5.01-5.75           | Fair Fairly     | Fairly substantial pollution likely    |
| 5.76-6.50           | Fairly poor     | Substantial pollution likely           |
| 6.51-7.25           | Poor very       | Very substantial pollution likely      |
| 7.26-10.00          | Very poor       | Severe organic pollution likely        |

3. Result and discussion

The examination of samples Gajah Wong river resulted in a total number of 29 families of benthic macroinvertebrates (Table 3). The total number of identified families varied among the sites. The lowest number of families found during the sampling at GW4 dan GW10 like 8 families, and the highest number of families found at GW1 like 13 families (Figure 1). The Plecoptera, Ephemeroptera and Trichoptera orders (EPT) were not absent at all stations (GW1 until GW10). Overall, the benthic macroinvertebrate communities of the Gajah Wong river were dominated by Hydropsychidae larvae (31.06%) and the second dominant taxa were Tubificidae (23.51%).
Table 3. Database of benthic macroinvertebrates families observed in the present study.

| No | Famil | GW1 | GW2 | GW3 | GW4 | GW5 | GW6 | GW7 | GW8 | GW9 | GW10 |
|----|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1  | Heptagenidae - A | 4   | 3   | 4   | 2   | 5   |     |     |     |     |     |
| 2  | Heptagenidae - B |     |     |     |     |     |     |     |     |     | 47   |
| 3  | Baetidae – A     | 26  | 18  | 16  | 11  | 6   | 8   |     |     |     | 40   |
| 4  | Baetidae – B     | 14  | 34  | 65  |     | 13  | 35  | 37  |     |     | 100  |
| 5  | Baetidae – C     |     |     |     |     |     |     |     |     |     | 2    |
| 6  | Caenidae         | 2   | 9   | 4   | 3   | 2   | 4   | 3   | 7   |     | 18   |
| 7  | Hydropsychidae   | 79  | 58  | 54  | 37  | 23  | 58  | 57  | 35  | 34  | 34   |
| 8  | Coenagrionidae - A | 1  |     |     |     |     |     |     |     |     | 1    |
| 9  | Libellulidae     |     |     | 1   |     |     |     |     |     |     | 1    |
| 10 | Noteridae        | 1   | 5   |     |     |     |     |     |     |     | 2    |
| 11 | Tipulidae – A    | 6   | 5   | 1   | 27  | 2   | 18  | 38  | 14  | 1   | 1    |
| 12 | Chironomidae red | 8   | 7   | 7   |     | 5   | 1   | 1   | 2   | 4   |     |
| 13 | Chironomidae white | 1  |     |     |     |     |     |     |     |     | 1    |
| 14 | Palaemonidae     |     |     |     |     |     |     |     |     |     | 1    |
| 15 | Parathelphusidae - A | 1  | 2   | 1   | 6   | 11  | 1   |     |     |     |     |
| 16 | Viviparidae      |     |     |     |     |     |     |     |     |     | 1    |
| 17 | Thiaridae – A    | 1   | 1   | 14  | 21  | 4   | 4   | 2   |     |     |     |
| 18 | Dugesiidae       |     |     |     |     |     |     |     |     | 1   |     |
| 19 | Erpobdelidae     | 15  | 1   | 3   | 4   | 2   | 1   | 1   | 4   | 5   |     |
| 20 | Tubificidae      | 2   | 3   | 29  | 158 | 64  | 7   | 13  | 7   | 39  | 33   |

Total number: 161, 145, 195, 242, 134, 109, 138, 115, 140, 131

Note: GW = Gajah Wong, the location is used as a place for data collection.

Table 3 is data collected from 10 stations. The composition and number of benthic macroinvertebrates are different, occur due to differences in habitat characteristics at each station. Benthic macroinvertebrates inhabitants of the river will make adjustments to the conditions of the aquatic environment [14]. In areas with a high level of pollution inhabited by animal groups that have high tolerance.

**Figure 1.** Graphic data of Gajah Wong river benthic macroinvertebrates.

According to the family biotic index, the stations GW2, GW3, and GW8 were of the water quality good, whereas the stations GW1, GW7, and GW6 were of the quality fairly good. Then the stations GW5 and GW10 were of the water quality fairly poor, the stations GW9 poor very, and finally station GW4
The water quality was very poor (Figure 2). The different levels of water quality variables indicative of water pollution are fluctuating from upstream to downstream stations.

The selection of 10 data collection stations based on the existing land use on the riverbank in Yogyakarta city to get data on different organisms. Station GW1, GW2, and GW3 is an area with quite a lot of vegetation around river, it is still found many organisms and still good water quality compared with other stations. Then at station GW4, GW5 become the poor station, because water quality is poor. There is full of waste that enters the river.

The degree of tolerance to environmental conditions at the family level is related to the diversity of species as well as the tolerance range of individual species within the family. Therefore, the scores at the family level usually represent intermediate values of species tolerance [15]. In this regard, indices at the family level may under- or overestimate water quality more than those based on species level. However, the use of indices at the family level may be adequate in terms of cost-efficiency, because they are easy to calculate and require less taxonomic knowledge when taxonomic experts are not available [1, 12, 16].

![Figure 2](image)

**Figure 2.** Result of analysis water quality of Gajah Wong river using Family biotic index.

GW1, GW2, GW3, GW6 and GW8 has the status of slightly polluted water quality because still EPT group. There dominates with Hydropsychidae and Baetidae. Aquatic habitat while the semi tolerant ones were Baetidae, Leptoceridae, and Hydropsychidae [17]. River conditions are still good with vegetation in several locations, not all riparian areas are covered by permanent structures.

Decrease in water quality occurs at stations GW4, GW5, GW9 dan GW10. The four research stations were categorized as heavily polluted with FBI value above 5.50. Water was declared substantial pollution likely, until Severe organic pollution likely. Gajah Wong downstream at stations GW4 and GW5 were 8.50 and 6.50, which suggests very poor severe organic pollution likely and very substantial pollution likely water quality. There dominates with tolerant benthic macroinvertebrates. According to Figure 3, we look at the Tubificidae group found 65.30% at GW4 and 47.76% at GW5. Oligochaeta, which are known to be able to tolerate unfavourable conditions such as low dissolved oxygen and high pollutant concentrations [18].

The stations GW4 and GW5 located downstream of the factory effluent discharge pipe. Besides that, the conditions on the left and right of the Gajah Wong river were already densely populated, throwing household waste into the river. All pollutant sources are united in the river. Pollutant sources in downstream areas, based on the data by Badan Lingkungan Hidup or environmental institution of Yogyakarta Special Region year 2015, consisted of hospitals, environmental and health laboratories, metal industries, leather industries, sugar industries, noodle industries, textile industries, alcohol industries, cow husbandries, slaughterhouses, fish canning
industries, tofu industries, tempeh industries, batik fabric industries, automotive industries, print shops, gas stations, car wash industries, pharmacies, hotels, and restaurants [19].

![Pie chart 1]

![Pie chart 2]

**Figure 3.** Percentage benthic macroinvertebrates at Gajah Wong river.

### 4. Conclusion
Gajah Wong river in Yogyakarta city, Indonesia was polluted based on benthic macroinvertebrates indicators (biomonitoring). The water quality status of each station determined using the family biotic index (FBI). Data at 10 stations resulted in different levels of pollution. From this study stations Gajah Wong 2 (GW2), GW3, and GW8 were of the water quality good, whereas the station GW1, GW7, and GW6 were of the quality fairly poor. Then the stations GW5 and GW10 were of the water quality fairly poor, the stations GW9 poor very, and finally station GW4 were of the water quality very poor, this can be seen in the result of the collected organism data, namely the majority is Tubificidae group found 65.30%. Suggestion for this study is necessary to regular monitoring rivers with biological components and increase the number of monitoring stations. Then carried out the arrangement of area around river and making domestic wastewater treatment installation to reduce the rate of pollution.

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