Structure and Distribution of Macrobenthos Community in Code River, Yogyakarta, Indonesia

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Abstract

This research aimed to explore the community structure of macrobenthos in Code River, Yogyakarta. This research was conducted during December 2019-January 2020 in Code River, Yogyakarta. Data was taken 4 times in 6 stations. Macrobenthos was taken using a Surber net with a size of 30 x 30 cm and sampling at 5 spots in each station. Data analysis consisted of density, diversity index, dominance index, and evenness index. Water quality data consisted of water temperature, flow velocity, water depth, water pH, dissolved oxygen, and organic matter. The results showed that the density of macrobenthos ranged from 54-172 ind/m². Our results showed that Code River has moderate diversity based on the Shannon-Wiener diversity index. Sulcospira testudinaria is the most dominant species in Code River. The evenness index showed high except at station 2 which was categorized as moderate. Code River has pretty good water quality, but stations 3, 4, and 5 which are located in the city area, it has a high organic matter content.

Keywords: abundance, organic compound, diversity, dominance, macrobenthos

INTRODUCTION

Code River is located in Yogyakarta Province in Indonesia (7°51'05.1"S 110°24'09.1"E), which has upstream at the foothills of Mount Merapi and the Opak area as downstream. The Code River crosses three districts in Yogyakarta which are densely populated with all its activities. Human activities affect river ecosystems such as changes in land use and modification of water resources that change the physical, chemical, and biological characteristics of the river ecosystems. Kiesel et al. (2019) also stated that river ecosystems are affected by global climate change, pollution, economy, human migration, and biota from outside the habitat. The high stress on river ecosystems due to the dynamics of current causes a significant increase in biomass, as well as reduced abundance and density of organisms (Sabater et al., 2018).

Macrobenthos are organisms that live attached to the substrate and in the sediment bed of the waters with a size of more than 2 mm (Borisov et al., 2016). Benthic animals have a role in the food chain as first and second consumers, or as food sources from higher trophic levels. Macrozoobenthos are deposit feeders (accumulators) and filter feeders (filters) (Ulfa et al., 2018). Macrobenthos inhabits a variety of substrates including mud, sand, sandstone, rocks, and rock edges (Abd Allah et al., 2018). Based on Peng et al. (2013), macrobenthos has an important position in ecosystems such as nutrient turnover,
pollutant metabolism, and secondary producers in marine sediments. The composition of the benthic macroinvertebrate family is used as an indicator of water quality because it is sensitive to water pollution (Zawiejska et al., 2012). Changes in the structure of the macrobenthos community have a good correlation with environmental factors. Macrobenthos can be used as bioindicators for monitoring and assessing the aquatic environment in river, sea, and lake ecosystems (Chen et al., 2018).

The limited movement of macrobenthos can be used to respond to environmental changes. The macrobenthos compositions that can be observed include species, diversity, abundance, and biomass (Chen et al., 2018). The abundance of macrobenthos is influenced by factors such as temperature, salinity, dissolved oxygen, sediment, and organic matter and no single factor can be considered as the main factor because these factors influence each other (Pawar & Al-Tawaha, 2017; Peng et al., 2013). Based on Noman et al. (2019), the abundance and distribution of macrobenthos depend on depth, tides, water flow, and nutrients. The species composition and density of macrobenthos change based on variations in water temperature, dissolved oxygen, depth, water flow, substrate quality, and mud. Macrobenthos density is also influenced by the availability of food resources (Weerman et al., 2011). This study aims to study the community composition of macrobenthos in the Code river and its relationship with water quality parameters.

METHODS

The research was conducted from December 2019 to January 2020 at the Code River, Yogyakarta. The study was divided into 6 stations that crossed the upstream, middle, and downstream parts by purposive sampling. Sampling was carried out every two weeks in the morning for 8 weeks.

Collection Samples

Macrobenthos were collected from 6 stations with 5 sampling points and taken using a 30 x 30 cm Surber net. The surfer net is placed and stretched on the bottom of the water with the net opening against the water current. The substrate in the surfer plot is stirred so that the macrobenthos leaves the substrate and enters the net bag. The attached macrobenthos was taken and preserved with 4% formalin. Macrobenthos identification was carried out at the Aquatic Ecology Sub-Laboratory of the Department of Fisheries UGM using the macrobenthos identification book of Freshwater Invertebrates of United States 2nd Ed.

![Figure 1. Sampling sites of macrobenthos in Code River, Yogyakarta](image)

Water Quality Parameters

Physical and chemical parameters serve as supporting data to strengthen the status of water quality including water temperature, current velocity, water depth, substrate type, pH, DO (Dissolved Oxygen), and an organic compound. Measurement of current velocity by the floating method and water depth was measured using a roll meter. Determination of the type of substrate by direct observation. Water temperature, pH, and DO (Dissolved Oxygen) are measured by Water Quality Checker (WQC AZ 86031), organic compounds were measured by titrmetric method.

Data Analysis

Macrobenthos density index was calculated by Welch (1948) using the following formula:

\[ K_i = \frac{10000}{B \times n} \times a \]  \hspace{1cm} (1)

Where \( K_i \) is density index (ind/m\(^2\)), 10000 is a conversion from cm\(^2\) to m\(^2\), \( B \) is surber net area, \( n \) is Number of sampling points, \( a \) is the number of macrobenthos individuals obtained.

Macrobenthos diversity can be calculated using the Shannon and Wiener diversity index by
Wilhm & Dorris (1966) using the following formula:

$$H' = -\sum \left( \frac{n_i}{N} \right) \ln \left( \frac{n_i}{N} \right)$$  \hspace{1cm} (2)

Where \(H'\) is the diversity index by Shannon-Wiener, \(n_i\) is the number of individuals of each species, \(N\) is the total number of individuals.

The Shannon-Wiener diversity index value category has a certain range of values, namely: \(H'<1\): Low diversity; \(1\leq H'\leq 3\): Moderate diversity; and \(H'>3\): High diversity.

The dominance of macrobenthos was carried out to analyze the dominance of certain species based on the Simpson Dominance Index by Litaay et al. (2017) with the following formula:

$$C = \sum \left( \frac{n_i}{N} \right)^2$$  \hspace{1cm} (3)

Where \(C\) is Simpson dominance index, \(n_i\) is the number of individuals of each species, \(N\) is the total number of individuals.

The Simpson dominance index value category has a certain range of values, namely: \(0<D\leq0.3\): Low dominance; \(0.3<D\leq0.6\): Moderate dominance; and \(0.6<D\leq1\): High dominance.

The evenness index of the Shannon-Wiener macrobenthos was calculated by Asriani et al. (2019) using the following formula:

$$E = \frac{H'}{\ln(S)}$$  \hspace{1cm} (4)

Where \(E\) is the Evenness index, \(H'\) is the Shannon-Wiener diversity index, and \(S\) is the number of species.

The Shannon-Wiener evenness index \(E\) indicates the distribution of individuals in given environment/habitat. \(E\) close to 0 = the distribution of individuals between species is uneven/there are certain dominant species; \(E\) is close to 1 = the distribution of individuals between species is even.

**RESULTS AND DISCUSSION**

Macrobenthos in the Code River Yogyakarta has various types and numbers at each station from upstream to downstream. The abundance of macrobenthos in Code River is presented in Figure 2, while the diversity, dominance, and evenness index are presented in Table 1.

![Figure 2. The abundance of macrobenthos in the Code river](image)

![Figure 3. The diversity, dominance, and evenness index of macrobenthos in Code river](image)

Water quality parameters include physical and chemical parameters. Physical parameters include water temperature, current speed, and depth. Chemical parameters include Dissolved Oxygen, pH, and Organic compound. Water quality parameters of Code River in each station can be seen in Table 1.

Table 1. Water quality parameters
The highest abundance of macrobenthos was found at 172 individuals/m². The most common species found at station 1 was *Sulcospira testudinaria* which is commonly found in Java and Sumatra Islands (Mustika *et al.*, 2019). According to Marwoto & Isnaningsih (2012), *S. testudinaria* has a wide distribution in Java Island and is tolerant to polluted water. Its habitat is in fast-flowing water such as rivers or rocky streams. The results show that the number of individuals of each species was high at station 1 even though the dominance was moderate. The location of the station is near fishery and rice fields and is characterized by sloppy topography with a fairly large river width. The river channel at station 1 has been modified by humans in which the river bank has been modified with concrete structure. The condition of the river is overgrown with riparian plants and large rocks that can be used by macrobenthos for shelter. Moreover, relatively high DO and low organic matter at station 1 is favorable for macrobenthos organisms. The dissolved oxygen content has a positive correlation with the abundance of macrobenthos (Figure 4). This finding was correlated with a high abundance of macrobenthos at station 1.

Station 2 has an abundance value of 150.56 individuals/m². The dominance index of station 2 is the highest with the lowest diversity and evenness index than the other stations. The condition of station 2 shows low species diversity due to the dominance of one species, even though the distribution of the number of individuals for each species is categorized as moderate. The location of station 2 is a sand and stone mining area, so the vegetation around the river is low in density. Sand mining causes changes in river banks and depths. These human activities affect the existence of producers as food sources so that station 2 has low diversity and dominance. Station 2 has a rocky substrate and lots of rocks blocking the river, therefore the organic matter is the lowest.

Station 3 has an abundance value of 105 individuals/m²; diversity index of 1.41 (medium); dominance index of 0.39 (medium); and an evenness index of 0.67 (high). Station 3 shows the distribution of the number of individuals of each species is high even though the dominance is moderate. Station 3 is located near hotels, hospitals, and people's homes. Station 3 has a rocky mud substrate. The most common types of macrobenthos found at this station are mollusks and arthropods. The abundance of arthropods is because they like rocky substrates (Marmita, 2013, as cited in Nangin *et al.*, 2015). The most common species found at station 3 was *Hydropsyche* sp. According to Tszydel *et al.* (2015), larvae of *Hydropsyche* sp. have a high level of tolerance for water contaminated by municipal and domestic sewage. *Hydropsyche angustipennis* can accumulate several heavy metals from polluted water. This is also supported by the presence of organic matter which is quite high at station 3 of 11.86 ppm.

### Table 1: Water Quality Parameters at Each Station

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Station 1</th>
<th>Station 2</th>
<th>Station 3</th>
<th>Station 4</th>
<th>Station 5</th>
<th>Station 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate</td>
<td>rocky</td>
<td>sand</td>
<td>muddy</td>
<td>rocky</td>
<td>sand</td>
<td>rocky</td>
</tr>
<tr>
<td>Water temp (°C)</td>
<td>27.59</td>
<td>27.53</td>
<td>27.64</td>
<td>28.61</td>
<td>29.26</td>
<td>29.02</td>
</tr>
<tr>
<td>Current speed (m/s)</td>
<td>0.44</td>
<td>0.48</td>
<td>0.59</td>
<td>0.38</td>
<td>0.43</td>
<td>0.38</td>
</tr>
<tr>
<td>Depth (m)</td>
<td>0.22</td>
<td>0.27</td>
<td>0.23</td>
<td>0.23</td>
<td>0.27</td>
<td>0.21</td>
</tr>
<tr>
<td>DO (ppm)</td>
<td>5.01</td>
<td>5.72</td>
<td>5.35</td>
<td>4.26</td>
<td>4.07</td>
<td>3.56</td>
</tr>
<tr>
<td>pH</td>
<td>7.15</td>
<td>7.48</td>
<td>7.43</td>
<td>7.57</td>
<td>7.53</td>
<td>7.48</td>
</tr>
<tr>
<td>Organic matter (ppm)</td>
<td>10.60</td>
<td>9.17</td>
<td>11.86</td>
<td>18.66</td>
<td>22.30</td>
<td>10.60</td>
</tr>
</tbody>
</table>

Figure 4. The correlation of organic matter and density of macrobenthos.
Station 4 has an abundance value of 67 individuals/m². The highest diversity of macrobenthos at station 4 was 1.75 in the medium category. Station 4 has the lowest dominance of 0.22 which is included in the category of low dominance index. Station conditions showed moderate diversity and high distribution of individual numbers so that no individual dominated. The most common types of macrobenthos found at this station are annelids and mollusks. The annelids found included *Tubifex* sp., *Erpobdella punctata*, *Placobdella hollensis*, and *Lumbricus* sp. Station 4 has a muddy substrate with an organic matter content of 18.66 ppm. River conditions at station 4 have high turbidity and are close to the sewage outlet. The high organic matter content at station 4 supports the higher diversity of macrobenthos at this station compared to other stations. Tubificidae can live in river water with high organic matter, high turbidity, muddy and low dissolved oxygen concentration.

Station 5 has an abundance value of 108 individuals/m²; diversity index of 1.70 (moderate); dominance index of 0.23 (low); and an evenness index of 0.82 (high). Station 5 shows the distribution of the number of individuals for each species is high and no dominant macrobenthos species. This condition indicates that the environment of station 5 has a wide range to be inhabited by various types of macrobenthos so that there is no dominance. Station 5 substrate is rocky mud. The most common types of macrobenthos found at this station are annelids and mollusks. The annelids found at station 5 were the most abundant than the other stations and the most species found was *Tubifex* sp. Tubificidae can live in river water with high organic matter. This is supported by the condition of organic matter at station 5 which is the highest among other stations, which is 22.30 ppm. The muddy substrate conditions are also suitable for the life of *Tubifex* sp. Dissolved oxygen concentration at station 5 is lower than other stations at 4.07 ppm. However, *Tubifex* sp. can live in conditions of low dissolved oxygen (Sharma & Chowdhary, 2011; Siahaan *et al.*, 2012).

The station that has the lowest abundance value is station 6, which is 54 individuals/m². The diversity index of station 6 of 1.26 is in the medium category. The dominance index with a value of 0.40 is in the medium category. Station 6 has a rocky sand substrate. The most common taxa are mollusks and annelids. Station 6 is near the aquaculture area and rice fields. The abundance of macrobenthos at station 6 is the lowest because it is located downstream so that a lot of organic material has accumulated at this station from the previous station. Organic matter has a negative correlation with the abundance of macrobenthos (Figure 5). Organic matter station 6 is 10.60 ppm and dissolved oxygen is 3.56 ppm. Pollutants in the water can reduce oxygen levels. Sources of polluted materials can be in the form of animal and human waste, garbage, and household and industrial waste. The accumulation of these pollutants reduces the dissolved oxygen content even more so that the dissolved oxygen value of station 6 is lower than the other stations (Putra *et al.*, 2014).

A total of 28 species of macrobenthos were identified from Code River with a total abundance of 658 individuals/m². The density of macrobenthos tended to decrease from upstream to downstream which could be due to declining water quality conditions. Code River passes through highly urbanized areas which have a significant impact on water quality, thus affecting the presence of macrobenthos. The results of the diversity index and dominance of the Code River are mostly in the medium category with the highest evenness index being the high category. The value of diversity and dominance in the Code River is inversely proportional. The increase of dominance index will be in tandem with the
decrease of diversity index due to the capability of benthic macroinvertebrates to respond to the disturbance from the environment (Sharma et al., 2011). In addition, the research conditions were at the beginning of the rainy season so that the abundance and diversity of macrobenthos fluctuated. The increase in rainfall affects the river flow more strongly so that macrobenthos is drifted away by the current. High current velocities can wash away macrobenthos that are not firmly attached to the rock (Pawar & Al-Tawaha, 2017; Siahaan et al., 2012). The rainy season affected some benthic macroinvertebrates found in lower abundance compared to the dry season. Some macrobentos is hiding behind rocks to withstand the current. Gastropod was the most commonly found during the rainy season meanwhile, some Arthropods will be drifted under strong current conditions otherwise they stick under the rocks. Variation of the bottom substrates probably controls the macrobenthos.

CONCLUSION

Our study revealed that the macrobenthos community in Code River was at moderate diversity as shown by Shannon-Wiener index ranged from 0.71-1.75. The community structure of macrobenthos in Code River was characterized by the abundance of Sulcospira testudinaria, and was influenced by water quality and the type of substrate. Dissolved Oxygen content has a positive correlation with the density of macrobenthos, while organic content has a negative correlation with the density of macrobenthos.

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REFERENCES


