Community structure of macrozoobenthos as bioindicator of pepe river quality, Mojosongo Boyolali

Udi Tarwotjo¹, Rully Rahadian², Mochammad Hadi³

¹,²,³Department of Biology, Faculty of Sciences and Mathematics, Diponegoro University, Semarang.

Abstract. The main problem that arises so far is the declining water quality of Pepe river due to increased human population and industrial activities along the Pepe River. This research was conducted in August 2017 using purposive random sampling method in three stations. The objective of this research is to provide basic information about the change of macrozoobenthos community structure which can be used as bioindicator of environmental quality in downstream of Pepe River. The results of this study showed that 72 macrozoobenthos species were found in 4 Class and 3 Fillum. The biological parameters showed that the upstream, center and downstream of the Pepe River was highly polluted, characterized by low diversity index, high density and high dominance index and low diversity. This study found three tolerant species that can be used as bioindicator of quality of water in the lower part of the Pepe River, i.e., Chirronomus sp, Pheretima sp, Cheumatopsyche, Melanoides maculata, Melanoides punctata and Thiara scabra. Based on the calculation of mFBI that can be used as an initial estimation of water quality status, Pepe river is very heavy polluted by organic matter.

Keyword: Macrozoobenthos, community structure, Pepe river

1. Introduction

Water is a natural resource that fulfills the livelihood of many people, so it needs to be protected to be beneficial for the life and life of human beings and other living creatures. It is necessary to conserve and control the water, to maintain water quality or achieve water quality so that it can be utilized sustainably by the level of water quality desired. Water quality management is done by efforts to control water pollution, that is by efforts to maintain water function so that water quality meets the quality standard. The relatively clean water is highly coveted by humans, both for daily living, industrial needs, for sanitation, and for agricultural purposes and so on [12]. One source of water that is widely used to meet the needs of human life and other living things is the river.

The river is one of the natural resources that flow, so the water treatment in the upstream will have an impact on the downstream. Upstream pollution will cause the social costs in the downstream (extremality effect), and upstream conservation will be beneficial in the downstream. The river is very beneficial for humans and beneficial for aquatic biota [4].

Pepe River is a tributary of Bengawan Solo River located in the west, flowing from west to east through Surakarta before reaching the estuary in Bengawan Solo. To control the flood, a straight fraction is built with the name Kali Anyar which is the alignment channel of the Tirtonadi River to the east. Pepe River receives waste loads from agricultural, textile, and batik industries, domestic activities and hospitals. Pepe River Outlet is located in the village Sangkrah, District Market Kliwon. The Pepe River that passes Solo City is black, the stream is small, and the sound of gurgling sounds when approaching indicates that time is shallow. The smell also stung. This river flows through the heart of the city while washed away the garbage with a black face thick in the dry period, and turned into brown in the rain. Pepe Mojosongo Boyolali River has been prepared to convert the regional...
designation into an agropolitan-based ecotourism area with various zones within it and is expected to become a new resource in the agriculture, fisheries and tourism sectors to improve the local economy. Pepe River can be used for tourist objects can also be used by residents for daily processed water supply needs. Furthermore, tourists will be able to down the Pepe river by boat as a means of water transportation [3].

Currently, water is a problem that needs to get serious attention because water has been polluted by the waste from various results of human activities, so to get good water by certain standards required a fairly expensive cost. Regarding quality, water resources have decreased. Similarly, in the quantity that already cannot meet the needs of human beings are increasing. River pollution is happening everywhere. River pollution in many parts of Indonesian has resulted in a clean water crisis. Water conditions that have decreased water quality can be monitored from various aspects such as physics, chemistry, and biology. Water quality monitoring physically or chemically can directly show the type of pollutants that cause water quality degradation. The result is a quantitative value so that it can be compared with the recommended limit. The disadvantages cost a lot because it must be done in the laboratory, besides the measurement is only a moment only so that the measurement must be done in the time series [2].

In addition to known from physicochemical parameters, changes in the quality of a water can also be known from the biological parameters that are based on the structure of the community of aquatic organisms that act as bioindicators. One of the aquatic organisms that can be used as bioindicator is benthic macroinvertebrate. Benthic macroinvertebrate is a relatively non-migratory and water-sensitive aquatic organism that can provide an overview of the physical, chemical, and biological conditions of aquatic [7].

Monitoring of biological conditions usually uses invertebrates. Macrozoobenthos belonging to invertebrate classes are easily identifiable because they are acroscopic in size and are more effective and efficient than in physics and chemistry [13]. The dominant group of organisms that make up macrofauna in the river bed with soft substrate consists of Insekta, Polychaeta, Crustacea, Mollusca. Macrobenthos animals throughout their lives act as benthos, some of which are m only really benthos in the larval stage or vice versa [10,16]. For example, Polychaeta worms generally live as benthos in adult stages, whereas demersal fish live as benthos in larval stages [17]. Fajri [9] states that in general, the composition of macrozoobenthos animals in all areas consists of groups Polychaeta 50-60%, while the rest are Mollusca, Crustacea, and Echinodermata [1]. Macrozoobenthos is relatively settled in an area so that it can present the condition of the area where the sample of the organism was taken [11].

Macrozoobenthos have very limited movement and persist in the area where they live and cannot dodge even though the place receives the input of pollutants. Macrozoobenthos is one of the aquatic organisms settled in the bottom of the waters that have relatively slow movement and long life cycle so that it can respond to water quality conditions continuously. The Family Biotic Index is indispensable in biomonitoring by classifying each finding, whereas the Bisel Biotic Index is based on the frequency of the number of taxa from the identified Insekta group [5] Problems. The deterioration in the quality of the aquatic environment can be identified from changes in the physical, chemical, and biological components of the coastal waters. Changes in the physical, chemical, and biological components in addition to decreasing the quality of the waters also cause the bottom of the waters (sediments) to decrease, which can affect the life of aquatic biota, especially on macrozoobenthos community structure [4].

2. Materials and Methods
Macrozoobenthos were taken using the Surber net. Macrozoobenthos sampling was performed three replicates in each point. The Surber net was placed on the bottom of the river, then the substrate was dredged so that macrozoobenthos joined netted in the net. The samples were then filtered with a 1.0 x 1.0 mm sieve. The filtrate was then given a 4% formalin solution that had been mixed with Rose Bengal dye. Makrobenthos samples were sorted by hand sorting method with the aid of the filter, then cleaned with distilled water and put into a sample bottle containing 70% alcohol as a preservative and labeled. Subsequently, the sample very heavy polluted by organic matter. Subsequently the sample was identified using book identification [8] conducted in Laboratory of Ecology and Biosystematic Diponegoro University. The following are the biotic index to be used as the basis for determining water quality by biomonitoring methods, as follows Interpretation mFBI to assess the water quality.
3. Results and Discussions

Water as a component of the environment which will affect and be influenced by other components. All living things need water to survive. But in reality, the water in the water receptors such as the river began to switch function and experienced contamination. The quality of river water in upstream, center and downstream areas has increased the pollution index. Therefore the analysis between the quantity and quality of Pepe River water in October with small discharges has increased the pollution load, especially in the downstream area. The color of the water is caused by the particles of decomposition of organic matter, natural metal ions (iron and manganese), plankton, humus, industrial effluents, and aquatic plants. Dissolved Oxygen / DO is the amount of oxygen contained in water and measured in units of milligrams per liter. This dissolved oxygen is used as a sign of the degree of waste contamination present, while the BOD indicates the amount of dissolved oxygen required by living organisms to break down or oxidize the waste materials in the water [13]. To monitor water pollution (river) used a combination of physical, chemical and biological parameters, but often only used physical parameters such as temperature, color, odor, taste, and turbidity of water. Or chemical parameters such as dissolved particles (DO), biochemical oxygen demand (BOD), suspended particles (SS), Ammonia (NH3).

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Biological parameters are still rarely used as pollution determinants. Whereas measurements using physical and chemical parameters only provide an overview of the quality of the aquatic environment for a moment and tend to produce results with interpretation in a wide range.

The results of the index of species diversity (H’), Uniformity (E’), and Dominance (C) indicates a difference. The Diversity Index ranges from 1,001 to 2,39, the lowest in st.1 (Upstream) of 1,001, the center is 1,98 and the highest on st. 3 (downstream) that is 2.39. Based on the highest evenness (E’) index at st.3 (0.92) and the lowest at st.1 (0.73). The highest dominant value is at st.3 (0.39) and lower at st.1 (0.13).

When viewed from the condition of station I, the low density of mollusca is due to the substrate conditions conditions are dominated by sand and gravel substrate. The stability of a community can be illustrated by the high value of uniform type index (E’) which, according to research results, the value of uniform index of station type 3 (downstream) 0.92, this indicates that the condition of the community is stable. The smaller the value of E’ indicates that the spread of the type is uneven, as in station 1 (upstream). When viewed from the condition of station I, low mollusca density is due to the substrate conditions conditions are dominated by sand and gravel substrate. The stability of a community can be illustrated by the high value of uniform type index (E’) which, according to research results, the value of uniform index of station type 3 (downstream) 0.92, this indicates that the condition of the community is stable. The smaller the E value indicates that the spread of the type is uneven, as in station 1 (upstream). The spread of species is also closely related to dominance, where if the value of small uniformity will occur the dominance of certain types. A dominance index value close to 1 indicates the presence of species dominating other species, while the dominant value of indicates almost no dominance of a species in the community. The presence of dominance indicates a very favorable environmental condition in favor of the growth of certain species of plant growth.
Table 1. Number of Individuals, Number of Species, Species Diversity Index (H'), Evennes Index (E'), and C (Dominance Index)

| Class       | Ordo                          | Family       | Species                        | Number of individual |
|-------------|-------------------------------|--------------|--------------------------------|----------------------|
|             |                               |              |                                | St. 1   | St. 2 | St. 3 |
| Gastropoda  | Sorbeoconcha                 | Thiaridae    | Melanoides maculata            | 3       | 9    |
|             |                               |              | Brotia testudinaria            | 1       | 2    |
|             |                               |              | Sulcospira sulcospira          | 2       | 3    |
|             |                               |              | Brotia spadicea                | 1       | 1    |
|             |                               |              | Thiara winteri                 | -       | 1    |
| Insekta     | Diptera                       | Cirronomidae | Psychodidae                    | -       | 3    |
|             |                               |              | Simulidae                      | 1       | 1    |
| Odonata     |                               | Euphaeidae   | Euphaeidae                     | 1       | 1    |
| Coleoptera  | Hemiptera                     | Dryopidae    | Dryopidae                      | -       | 1    |
|             |                               | Heptageniidae| Ephemeraella sp                | 1       | 3    |
|             |                               | Caenidae     | Caenodes sp                    | 1       | 2    |
|             |                               |              |                                | 3       | 5    |
| Trichoptera | Oligochaeta                   | Ophistidae   | Perethima                      | 1       | -    |
| Crustacea   | Decapoda                      | Portunidae   | Podophtthalmus vigil           | -       | -    |

Based on the results of the study, there were 121 individuals of 44 species of Gastropoda dominated by Melanoides, 71 species of Insekta dominated by Chironomus, eight species of Oligochaeta dominated by Perethima and one species of Crustacea. From these data, it is shown that the composition of the macrozoobenthos animal grouping classes in the three research sites is different. Differences in the composition of the constituent classes of the communities from both locations are thought to be caused by physical factors that are physical characteristics of both locations. In addition to the different physical characteristics of the coast, differences in the composition of the constituent classes of the communities in both locations are also suspected to be caused by differences in the basic substrate of community constituents. Nybakken [14] explains that the basic substrate is one of the major ecological factors affecting macrobenthos community structures. The spread of macrobenthos can be correlated with the substrate type. Macrobenthos that have the property of deposit-feeding tend to be abundant in the mud sediments and soft sediments which are areas containing high organic matter. Odum [15] suggests that the base substrate or soil texture is an important component of organism life. The substrate at the bottom of the waters will determine the abundance and species composition of the benthos animal [18]. Nybakken [14] states the density of a species is also influenced by several ecological factors such as adaptability, substrates that support for life, and other natural factors.

Water Quality Assessment with mFBI value
Water quality testing with the Modified Family Biotic Index in the Pepe River during the study has decreased water quality. In the Upper River Pepe the mFBI value of 5.75 (medium polluted), in the middle of the river the value of mFBI is 6.21 (the water quality is inadequate), whereas, in the downstream, it is 8.15 (the water quality is ugly).
### Table 2. Water quality assessment using mFBI in upstream area of Pepe river

| No | Family  | EPT      | Number of individual | Tolerance index | JI X IT |
|----|---------|----------|----------------------|-----------------|--------|
| 1  | Euphaeidae | Odonata  | 1                    | 7               | 7      |
|    | Libellulidae |         | 1                    | 7               | 7      |
|    | Gerridae    | Hemiptera | 3                    | 5               | 15     |

N= 5  
T=26  
FBI = T/N = 5.20

### Table 3. Water quality assessment using mFBI in the middle area of Pepe river

| No | Family  | EPT      | Number of individual | Tolerance index | JI X IT |
|----|---------|----------|----------------------|-----------------|--------|
| 1  | Thiaridae | Sorbeoconcha | 3                    | 7               | 21     |
|    |          |          | 1                    | 7               | 7      |
|    |          |          | 2                    | 7               | 14     |
|    |          |          | 1                    | 7               | 7      |
|    |          |          |                      | 7               | 0      |
|    |          |          | 3                    | 7               | 21     |
|    |          |          | 1                    | 7               | 7      |
|    |          |          |                      | 7               | 0      |
| Cirronomidae | Diptera | 9                    | 8               | 72     |
| Simulidae    |          | -                    | 3               | 0      |
| Psychodidae  |          | 1                    | 3               | 3      |
| Euphaeidae   | Odonata  | 1                    | 7               | 7      |
| Libelulidae  |          | 1                    | 7               | 7      |
| Dryopidae    | Coleoptera |                      | 3              | 0      |
| Gerridae     | Hemiptera | 2                    | 6               | 12     |
| Heptageniida | Ephemeroptera | 1                   | 6              | 6      |
| Caeniidae    | Trichoptera | 1                   | 5              | 5      |
| Ophistidae   | Ophistophora | 3                | 6              | 18     |
| Portunidae   | Decapoda  | 1                    | 5               | 5      |

33   
T = 205  
FBI = T/N = 6.21

### Table 4. Based on water quality assessment with mFBI in the downstream area

| No | Family  | Ordo  | Number of individual | Tolerance index | JI X IT |
|----|---------|-------|----------------------|-----------------|--------|
| Thiaridae | Sorbeoconcha | 9     | 7                    | 63              |
|          |          | 2     | 7                    | 14              |
|          |          | 3     | 7                    | 21              |
|          |          | 1     | 7                    | 7               |
|          |          | 1     | 7                    | 7               |
|          |          | 7     | 7                    | 49              |
|          |          | 3     | 7                    | 21              |
|          |          | 4     | 7                    | 28              |
| Cirronomidae | Diptera | 39    | 8                    | 312             |
| Simulidae  |          | 3     | 3                    | 9               |
| Psychodidae |    | 1     | 3                    | 3               |
| Euphaeidae | Odonata  | -     | 7                    | 0               |
| Libelulidae | | -     | 7                    | 0               |
| Dryopidae  | Coleoptera | 1    | 3                    | 3               |
| Gerridae   | Hemiptera  | -    | 6                    | 0               |
| Heptageniida | Ephemeroptera | 3   | 6                  | 18              |
| Caeniidae  | Trichoptera | 2    | 5                    | 10              |
| Ophistidae | Ophistophora | 5    | 6                    | 30              |
| Portunidae | Decapoda  | -    | 5                    | 0               |

N= 73  
T = 595  
FBI = T/N = 8.15
At station I (upstream), Euphaeidae and Libellulidae (Odonata) and Gerridae (Hemiptera) were found. They are bioindicators of lightly contaminated waters. At station II (middle area) and station III (downstream) genus Melanoides from Thiaridae family was found. This genus is an active animal at night (nocturnal). Melanoides have an operculum that can protect themselves from drought so that it can survive on dry land and high salinity. In addition, this operculum can increase tolerance to toxic chemicals in the environment, so this taxa can be used as a bioindicator of polluted aquatic ecosystems. It also found Chironomidae which is a moderate to severe polluted water indicator.

Based on water quality assessment with mFBI it is known that at st. 1 (upstream) is 6.5 means the quality of polluted water is medium, at station 2 (center) is 6.21 means water quality is rather bad and downstream water quality, mFBI value is very bad.

4. Conclusion

The macrozoobenthos Community Structure (H ’, E’, C) in the Lower Region is higher than the Upper or Central of the Pepe River. Differences in the composition of the constituent classes of the communities in both locations are also thought to be caused by differences in the basic substrate of community constituents. Based on water quality assessment with mFBI it is known that at st. 1 (upstream) the quality of polluted water is moderate, at station 2 (center) water quality is rather bad and downstream water quality very bad.

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