Water Quality Analysis Based on Diversity and Abundance of Macrozoobenthos in the Way Semah River Pesawaran

(Analisis Kualitas Air Berdasarkan Keanekaragaman Dan Kelimpahan Makrozoobentos di Perairan Sungai Way Semah Pesawaran)

Tazranisa Indy Irawan, Tugiyono*, Suratman Umar, Gregorius Nugroho Susanto

Biology Department, Faculty of Mathematics and Natural Sciences, University of Lampung
*Corresponding author: tugiyono.1964@fmipa.unila.ac.id

Abstract

River pollution can occur due to human activities in the surrounding areas who do not care about the aquatic environment. As a result, water quality decreases and river ecosystems are damaged and water biota such as macrozoobenthos are reduced. The aim of this research is to determine the diversity and abundance of macrozoobenthos as well as the level of water pollution in the Way Semah Pesawaran River. In this study, three water quality indicators were examined, namely biological (macrozoobenthos), physical (temperature, brightness) and chemical (pH, DO and BOD). Sampling was carried out at three stations consisting of two spots, namely on the right bank and the left bank of the river. Location determination and data collection were carried out using the purposive sampling method. The results show that the abundance, diversity, uniformity and dominance of macrozoobenthos in the Way Semah River ecosystem is lightly to moderately polluted with a range of 1.21 – 1.87. Physical parameters include temperature ranging from 27-28°C, transparency ranging from 35-55 cm. Chemical parameters such as pH are 6-7, DO between 3.2-3.3 and BOD between 14-32 mg/L.

Keywords: Way Semah River, Macrozoobenthos, River Pollution

INTRODUCTION

The accessibility of rivers makes them essential for daily activities, leading to an extensive economic and industrial development along their banks. However, the long term that are uncontrollable of human activities can result in water pollution, significantly impacting water quality [1]. Poor water quality will change the physical, chemical, and biological characteristics of a river, leading to habitat destruction and the loss of river biotas which one of them is macrozoobenthos.

Macrozoobenthos is aquatic organisms that are inhabiting the bottom of waters. Their movements are relatively slow but have a relatively long-life span so they can be used as indicator water quality changes [2]. In unpolluted waters, macrozoobenthic populations are evenly distributed among species. Conversely, in the polluted waters they show an uneven population distributions, and leading to dominance by certain species [3].

The Way Semah River is a part of the Way Sekampung watershed, covering a total area of 484,132 hectares. The Way Semah sub-watershed has experienced vegetation decline due to the conversion of forest and scrub lands for agriculture, plantations, housing, and industry [4]. The activities that lack of consideration for water resource and environmental preservation caused the degradation water quality of the Way Semah sub-watershed.

This research aims to determine the diversity and abundance of macrozoobenthos in the Way Semah River, located in Pesawaran Regency. Additionally, this study also assess pollution levels of water in the Way Semah River based on macrozoobenthos diversity and abundance, as well as physical (temperature and transparency) and chemical parameters including pH, dissolved oxygen (DO) and biological oxygen demand (BOD).

METHODS

Study area

This research was conducted from November to December 2023 in the Way Semah River, located in Pesawaran Regency.

To determine location and collecting data the purposive sampling method was used. The research location was divided into three stations, as follows:

a. ST 1: Upper Way Semah River, located near residential areas in Sinar Baru Hamlet, Negara Saka Village, Negeri Katon District, Pesawaran Regency.

b. ST 2: Middle Way Semah River, located near home industries in Bumi Jaya Hamlet, Negeri Ulangan Jaya Village, Negeri Katon District, Pesawaran Regency.

c. ST 3: Lower Way Semah River, located near agricultural land in Kresnowidodo Village, Tegineneng District, Pesawaran Regency.

Each station had two sampling spots: the right bank and the left bank, resulting in a total of 6 sampling spots. The locations of the sampling spots are showed in Figure 1.
Macrozoobenthos sampling was performed three times in two-week. The animal samples were collected using an Eckman grab, which was lowered to the river bed to dredge up sediment. The sediment then filtered through a 1 mm sieve net to separate the benthos. The collected samples were placed into sample bags and preserved with 4% formalin as a fixing agent. Samples were identified using the "Freshwater Invertebrates of the United States Second Edition" identification book by Robert William Pennak (1978), and the number of individuals was counted at the Zoology Laboratory, Faculty of Mathematics and Natural Sciences, University of Lampung.

Water physical quality parameters such as water temperature and transparency were measured directly in the field. Water temperature measured using a thermometer, while water transparency was assessed using a Secchi disk.

Chemical parameters such as pH and dissolved oxygen (DO), were also determined directly at the research location of the Way Semah River. Biological Oxygen Demand (BOD) was measured at the UPTD Laboratory Center in Bandar Lampung City.

Data analysis

**Abundance Index (individuals/m²)**

To determine the abundance of macrozoobenthos individuals per unit area, the Welch formula was used as follows:

\[ N = \frac{a}{O \times S} \times 10,000 \]

- \( N \) = Average number of individuals per meter\(^2\)
- \( a \) = Number of macrozoobenthic individuals counted
- \( O \) = Ekman grab opening area
- \( S \) = Number of samples for each observation station

**Diversity Index (H')**

To determine the variety of macrozoobenthos species at each station, the Shannon-Wiener formula was used following Odum (1993) as follows:

\[ H' = -\sum_{i=1}^{S} P_i \ln P_i \]

- \( H' \) = the Shannon diversity index
- \( P_i = \frac{n_i}{N} \) (fraction of the entire population made up of species \( i \))
- \( n_i \) = numbers of species \( i \)
- \( N \) = total number of individuals (total abundance)
- \( S \) = numbers of species
The Shannon-Wiener index value can be divided into the following categories:

- $H' < 1$: low diversity
- $1 < H' < 3$: moderate diversity
- $H' \geq 3$: high diversity

The Diversity Index values can be used to classify the level of water pollution according to Lee et al. (1978) as follows:

- $>2,0$: unpolluted
- $1,6 - 2,0$: moderately polluted
- $1,0 - 1,5$: polluted
- $<1,0$: severely polluted

**Uniformity Index (E)**

To assess the community balance or similarity in the number of individuals between species, the Shannon-Wiener formula was used following Odum (1993):

$$E = \frac{H'}{H_{\text{max}}} = \frac{H'}{\ln S}$$

- $E$: uniformity index
- $H'$: Shannon diversity index
- $H_{\text{max}}$: maximum diversity
- $S$: number of species

The Shannon-Wiener index value can be categorized into categories as follows:

- $E < 0,40$: low uniformity
- $0,40 < E < 0,60$: moderate uniformity
- $E \geq 0,60$: high uniformity

**Dominance Index (C)**

To determine which species dominate a community, the Simpson formula was used:

$$C = \sum_{i=1}^{n} \left( \frac{n_i}{N} \right)^2$$

- $C$: dominance index
- $n_i$: number of individuals of each species $i$
- $N$: total number of individuals across all species

The Simpson index value can be categorized into specific ranges below:

- $C < 0,50$: low dominance
- $0,50 < C < 0,75$: moderate dominance
- $0,75 < C < 1,00$: high dominance

**Correlation Analysis**

Correlation analysis is employed to assess the strength of the relationship between two variables, with values ranging from 0 to 1. A value closer to 1 indicates a stronger correlation between variables, while a value closer to 0 indicates a weaker correlation. To examine the correlation between the community structure of macrozoobenthos and physical and chemical factors, Pearson correlation was used [24]. IBM SPSS Statistics 29 was utilized for the correlation analysis in this study.

**RESULTS AND DISCUSSION**

**Identification of Macrozoobenthos**

There are 9 species of 7 families from 4 classes of macrozoobenthos found in this study. The types and number of macrozoobenthos individuals found in this study are presented in Table 1.

<table>
<thead>
<tr>
<th>Class</th>
<th>Family</th>
<th>Species</th>
<th>Station</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Gastropods</td>
<td>Viviparidae</td>
<td>Filopaludinasumatrensis</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bellamya sp.</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Thiaridae</td>
<td>Melanooidestuberculata</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Melanooidesturricula</td>
<td>7</td>
</tr>
<tr>
<td>Physidae</td>
<td></td>
<td>Physasp.</td>
<td>8</td>
</tr>
<tr>
<td>Ampullaridae</td>
<td>Pomaceacanaliculata</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Bivalvia</td>
<td>Corbiculidae</td>
<td>Corbicula fluminea</td>
<td>50</td>
</tr>
</tbody>
</table>
Abundance Index (H’)

Abundance is the number of individuals of a species in a place expressed by the number of individuals per unit area or volume [7]. Abundance was analyzed by calculating the average number of macrozoobenthos individuals per unit area (m²) and its values are in Table 2.

Table 2. Fertility Index (N) at All Three Stations

<table>
<thead>
<tr>
<th>Species</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Filopaludinasumatrensis</em></td>
<td>35</td>
<td>33</td>
<td>-</td>
</tr>
<tr>
<td><em>Bellamy sp.</em></td>
<td>33</td>
<td>32</td>
<td>-</td>
</tr>
<tr>
<td><em>Melanoides tuberculata</em></td>
<td>21</td>
<td>23</td>
<td>86</td>
</tr>
<tr>
<td><em>Melanoides turricula</em></td>
<td>9</td>
<td>6</td>
<td>19</td>
</tr>
<tr>
<td><em>Physasp.</em></td>
<td>10</td>
<td>38</td>
<td>-</td>
</tr>
<tr>
<td><em>Pomacea canaliculata</em></td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td><em>Corbicula fluminea</em></td>
<td>62</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Tubifex sp.</em></td>
<td>28</td>
<td>31</td>
<td>44</td>
</tr>
<tr>
<td><em>Chironomus sp.</em></td>
<td>9</td>
<td>11</td>
<td>24</td>
</tr>
<tr>
<td>Number of Ind/m² (N)</td>
<td>207</td>
<td>175</td>
<td>173</td>
</tr>
</tbody>
</table>

The highest abundance of macrozoobenthos was found at Station I, in which there are 207 individuals per square meter (Ind/m²). The high abundance of macrozoobenthos at this
station may be due to better environmental conditions compared to other stations. This can be seen from the physical and chemical properties of water. Water clarity is quite high with a Secchi disk value of 55 cm. The dissolved oxygen (DO) content is still quite high, namely 3.3 mg/L. Biological oxygen demand (BOD) is relatively low, measurements through titration at the UPTD Laboratory in Bandar Lampung City found a value of 14 mg/L. These favorable water conditions support aquatic biota, including macrozoobenthos [8].

In contrast, the lowest abundance of macrozoobenthos was found at Station III, with a value of 173/m². This condition may be related to the fact that Station III is affected by changes of river flow from upstream to downstream. The relatively low current in this area affects the substrate for macrozoobenthos, resulting in a lower abundance. The changes of river flow also lead to reduce nutrient intake, impacting macrozoobenthos abundance. Apart from that, during the rainy season, water from the upstream flows waste to the downstream, making the river water cloudy and reducing light penetration, thereby disrupting the aquatic ecosystem [9].

Diversity, Uniformity and Dominance of Macrozoobentos
The diversity index values at stations I-III are 1.87, 1.85, and 1.21 respectively, indicating a moderate level of diversity. The uniformity index values at these stations were 0.90, 0.89, and 0.87 respectively, showing relatively high uniformity. The dominance index values at the same stations were 0.17, 0.16, and 0.34 respectively, indicating a low level of dominance. The diversity index of macrozoobenthos in the Way Semah River ranges from 1.21 to 1.87, classified as moderate. According to Lee et al. (1978)’s classification of pollution levels based on the diversity index, the water quality in the Way Semah River is categorized as lightly to moderately polluted. Moderate diversity indicates a variety of species types and relatively unstable macrozoobenthos variations. This shows that the ecosystem is lightly to moderately polluted [10], with good macrozoobenthic productivity and moderate ecological pressure, making the ecosystem in equilibrium.

The diversity of macrozoobenthos is highly dependent on its tolerance and sensitivity to environmental factors [11], including water transparency, substrate type, physical-chemical factors, and pollutants [12].

The uniformity of macrozoobenthos at the three stations in the Way Semah River is classified as high uniformity, ranging from 0.88 to 0.90. A high uniformity index indicates an even distribution of macrozoobenthic species without dominance by certain species. Homogeneous physical and chemical factors contribute to the high evenness of organisms in ecosystems [13]. Uniformity indices are useful for predicting species dominance in an environment; low uniformity indicates the dominance of one or a few species [14].

The macrozoobenthos dominance index in the Way Semah River ranges from 0.16 to 0.33, which is in the low category. A low dominance value indicates the absence of a dominant species in an ecosystem. The level of dominance is closely related to the uniformity index: high uniformity corresponds to low dominance (close to 0), while low uniformity indicates high dominance (close to 1) [15].

Ecological Factors and Water Quality
Physical and Chemical Parameters
This study analyzes various physical and chemical parameters. Physical parameters include temperature and transparancy, while
chemical parameters include pH, dissolved oxygen (DO), and biological oxygen demand (BOD). The values of these parameters are summarized in Table 3.

Table 3. Physical and Chemical Parameters

<table>
<thead>
<tr>
<th>Physical and Chemical Parameters</th>
<th>Station</th>
<th>Quality Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>Brightness (cm)</td>
<td>55</td>
<td>47.5</td>
</tr>
<tr>
<td>pH</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>DO (mg/L)</td>
<td>3.3</td>
<td>3.2</td>
</tr>
<tr>
<td>BOD (mg/L)</td>
<td>14</td>
<td>30</td>
</tr>
</tbody>
</table>

*Government Regulation No. 22 of 2021 Class II

Temperature at the three stations showed consistent results in the range of 27 to 28°C. Temperature plays a crucial role in aquatic biota, influencing metabolic activities and gas reactions. Even slight changes in temperature can impact these activities [16]. The optimal temperature range for macrozoobenthos growth is ranged 25 and 32°C [14].

The water transparency value ranges from 35 cm to 55 cm at the three stations. Low transparancy indicates higher levels of suspended particles in the water, which can negatively impact aquatic organisms [17]. Higher brightness levels generally support better aquatic life [18].

The pH at the three stations ranges from 6 to 7, with Station I showing the highest and optimal pH value. The pH value is influenced by biological activity, photosynthesis, temperature, and oxygen content. A pH range between 7 and 9 is considered optimal for macrozoobenthos growth [19]. The pH value is very important for nutrient availability and toxicity in the aquatic environment [15]. pH variations can be influenced by pollutants, photosynthesis, and temperature changes.

Dissolved oxygen (DO) levels at all three stations were ranging from 3.2 to 3.3 mg/L. These values indicate relatively low oxygen levels, which suggest highly polluted water quality [20]. Water depth also affects DO levels; deeper waters generally have lower DO due to reduced photosynthesis and increased organic matter oxidation [21]. BOD levels were 14 mg/L at Station I, 30 mg/L at Station II, and 32 mg/L at Station III. These levels exceed quality standards, indicating high organic matter content in the water. Elevated BOD levels can be attributed to human and industrial activities near the research stations [22]. High BOD levels reduce dissolved oxygen, impairing aerobic decomposition of organic waste and potentially damaging river ecosystems [23].

Pearson Correlation between Macrozoobenthos Community Structure and Water Quality

The relationship between macrozoobenthos and water quality indicators was assessed using the Pearson correlation method with IBM SPSS Statistics 29 software. The results of the correlation analysis are summarized in Table 4.
Table 4. Correlation between Macrozoobentos and Water Quality of the Way Semah River

<table>
<thead>
<tr>
<th></th>
<th>Temperature</th>
<th>Brightness</th>
<th>pH</th>
<th>DO</th>
<th>BOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Pearson Correlation</td>
<td>-.545</td>
<td>.817</td>
<td>.999*</td>
<td>.999*</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.633</td>
<td>.391</td>
<td>.033</td>
<td>.033</td>
<td>.031</td>
</tr>
<tr>
<td>N</td>
<td>H' Pearson Correlation</td>
<td>-1.000*</td>
<td>.938</td>
<td>.523</td>
<td>.523</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.017</td>
<td>.225</td>
<td>.650</td>
<td>.650</td>
<td>.585</td>
</tr>
<tr>
<td>N</td>
<td>E Pearson Correlation</td>
<td>-.945</td>
<td>.999*</td>
<td>.756</td>
<td>.756</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.212</td>
<td>.030</td>
<td>.454</td>
<td>.454</td>
<td>.390</td>
</tr>
<tr>
<td>N</td>
<td>C Pearson Correlation</td>
<td>.999*</td>
<td>-.908</td>
<td>-.454</td>
<td>-.454</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.033</td>
<td>.275</td>
<td>.700</td>
<td>.700</td>
<td>.635</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Note:
N : Macrozoobentos Abundance Index (individuals/m²)
H' : Macrozoobentos Diversity Index
E : Macrozoobentos Uniformity Index
C : Macrozoobentos Dominance Index

Analysis of the correlation between temperature and macrozoobentos diversity produces $r=-1.000, p=0.017$. This negative correlation indicates that high environmental temperatures result in low macrozoobentos diversity. An increase in water temperature can be caused by pollutants such as household and industrial waste, causing a decrease in dissolved oxygen levels and disrupting the sustainability of macrozoobentos and aquatic plants [24].

The correlation between temperature and macrozoobentos dominance is $r=0.999, p=0.033$. This positive correlation shows that the higher environmental temperature is related to the higher dominance of macrozoobentos. Increasing temperatures can reduce abundance and diversity, thereby favoring species that are tolerant to changes in environmental temperature. Dominant species show varying adaptability between species [25]. The correlation between water transparency and macrozoobentos uniformity is $r=0.999, p=0.030$. This positive correlation indicates that higher water transparency increases the macrozoobentos uniformity index. Water brightness is an indicator of water clarity and influences light penetration which in turn has an impact on macrozoobenthic life [2].

The correlation between pH and macrozoobentos abundance was $r=0.999, p=0.033$ indicating a positive correlation. This means that higher pH values are associated with higher macrozoobentos abundance. Aquatic organisms have varying abilities to tolerate water pH levels. Low pH values can be lethal to aquatic organisms [11]. Conversely, lower pH values can increase water acidity, which can promote macrozoobentos abundance [26]. The pH range of 7-9 is generally conducive to the growth and development of macrozoobentos.

The correlation between DO and macrozoobentos abundance was $r=0.999, p=0.033$ indicating a positive correlation. This
means that the higher the DO level, the higher the abundance of macrozoobenthos. The dissolved oxygen content greatly influences the number and diversity of macrozoobenthos in a water body [13]. Dissolved oxygen levels above the standard threshold of 4 mg/L, according to Government Regulation Number 22 of 2021, are the minimum oxygen levels required to support the activities of macrozoobenthic organisms. Higher dissolved oxygen content supports better conditions for macrozoobenthic life [27].

The correlation between BOD and macrozoobenthos abundance is negative with \( r = -0.999 \) and \( p = 0.031 \). The higher the BOD level, the lower the macrozoobenthos abundance index value. High BOD levels indicate a high level of pollution in the waters. The increase in waste material in waters causes reduced dissolved oxygen levels which can affect the number, diversity and death of aquatic organisms, including macrozoobenthos.

**CONCLUSION**

The conclusion of this research is that macrozoobenthos diversity in the Way Semah River, Pesawaran Regency, Lampung is moderate at all three stations, with diversity index values of 1.87, 1.85 and 1.21 respectively. The relative abundance of macrozoobenthos varied at the three stations with values of 205, 175, and 173 individuals per square meter (ind/m²). Based on macrozoobenthos diversity, the level of pollution in the Way Semah River is classified as lightly to moderately polluted with diversity index values ranging from 1.21 to 1.87.

**REFERENCES**

[1] H. Rachman, A. Priyono dan Y. Wardiatno, "


Water Quality Analysis Based on...


[18] M. Pramleona, N. Yuliani, R. Arizal dan S. E. Wardoyo, "Parameter Fisika Dan Kimia Air Kolam Ikan Nila Hitam (Oreochromis niloticus)", *Jurnal Sains Natural Universitas Nusa Bangsa*, vol. 8, no. 1, hlm. 24-34, Januari 2018. [https://doi.org/10.31938/jsn.v8i1.107](https://doi.org/10.31938/jsn.v8i1.107)

[19] Y. Y. Amin, Jamaluddin dan E. S. Kaseng, "Keanekaragaman Makrozoobentos Seba..."


