Habitat characteristic of macrozoobenthos in Naborsahan River of Toba Lake, North Sumatra, Indonesia

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Abstract. This research described the relative abundance, dominance index, and index of macrozoobenthos equitability in Naborsahan River of Toba Lake, North Sumatra, Indonesia. The purposive random sampling at three stations was used to characterize the biological, chemical, and physical parameters of macrozoobenthos. The highest relative abundance of macrozoobenthos found at station 2 (99.96%). By contrast, the highest dominance index was at station 3 (0.31), and the maximum equitability index found at station 1 (0.94). The present results showed diversity parameters among the stations. A principal component analysis (PCA) was used to determine the habitat characteristics of macrozoobenthos. PCA analysis depicted that six parameters studied, brightness, turbidity, depth, temperature, dissolved oxygen (DO) and biochemical oxygen demand (BOD_5) play a significant role on the relative abundance, dominance index, and equitability index. PCA analysis suggested that station 3 was suitable habitat characteristic for the life of macro-zoobenthos indicating of the negative axis. The present study demonstrated the six parameters should be conserved to support the survival of macrozoobenthos.

1. Introduction

Toba Lake is the largest lake in Southeast Asia, and the deepest lake in the world which was formed 75,000 years ago after an earth splitting volcano eruption [1]. The Toba Lake located at seven Regencies of North Sumatra province. Patterns of streams in the inlet of Toba Lake is dominated by small rivers, with a total of 289 streams. Among them is the famous Naborsahan River which is one of the inlets of Toba Lake.

The river formed aquatic ecosystems to play a significant role in the hydrological cycle and serves as a water catchment area for the adjacent lake [2]. The environmental characteristics strongly influence the condition of a river. River waters have biotic and abiotic components interact to form ecosystems which mutually changed [3]. Macrozoobenthos was known as bioindicators to evaluate freshwater bodies receiving domestic and industrial waste matters [4]. Based on its size, macrozoobenthos is very easy to identify and sensitive toward the environment change. The size of macrozoobenthos (animals at least 2 mm in size) can reach at least 3 to 5 mm at the maximum growth [5]. To get more insight into ecosystem function of the Inlet of Toba Lake the habitat characteristics of macrozoobenthos surrounding of Toba Lake was studied. This present research aimed to characterize

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the biological, chemical, and physical parameters of macrozoobenthos in Naborsahan River of Toba Samosir, North Sumatra, Indonesia.

2. Materials and Method

2.1. Time and Location Research

This study was conducted in April-June in Naborsahan River of Toba Samosir, North Sumatra. Sampling was carried out at three stations. Macrozoobenthos was sampled from the middle to downstream of the Naborsahan River to characterize the biological, chemical, physical parameters of macrozoobenthos. Three locations were determined with each distance 1-1.5 km. Station 1 located at 02º 39' 06.5" North latitudes and 098º 56' 12.7" East longitudes with sand dominated. Station 2 sited at 02º 39' 12.4" North latitudes and 098º 56' 06.6" East longitudes with sand substrate. Station 3 situated at 02º 39' 19.1" North latitudes and 098º 56' 03.6" East longitudes with mud substrate.

2.2. Measurement of the parameters

Physical and chemical parameters were measured at each station. Measurement of the parameters was performed *in situ* namely temperature, currents, depth, brightness, pH, and DO (dissolved oxygen) as previously described [5]. Furthermore, C-organic content, turbidity, COD (chemical oxygen demand), and BOD_5 (biological oxygen demand) were conducted *ex situ* as previously reported [5].

2.3. Macrozoobenthos measurement

Each station was divided into 4 points analysis as quintuplicate to identify and measure macrozoobenthos. Eikman Grab was used both to take macrozoobenthos (ind/m^2) samples and substrate. Samples were obtained at each point to be sorted accordingly to its morphology such as shape, colour, and size for data analysis as previously described [6].

3. Results and Discussion

3.1. Physical and chemical parameter of macrozoobenthos

The measurement of temperature at all stations was 23-25 ^oC (Table 1). It has been reported the optimal temperature range for macrozoobenthos growth between 20-30 ^oC [6]. Naborsahan River, therefore, had good water quality due to the development of macrozoobenthos. Table 1 shows the values of current velocity was 0.23 to 0.44 m/s. The current speed affected the spread of macrozoobenthos [7]. Current velocity speed caused the spread of the genus macrozoobenthos each station was different. The entire depth ranged from 55-88.9 cm each site. Position 3 was the deepest position because it was at the mouth of the river and the inlet of Lake Toba with a height that reaches 905 m elevation above sea level. Water transparency depends on the turbidity [3]. The results of brightness measurements from 49.3-55.9 cm. The entire station indicated clear water as the result of depth and light did not show a significant difference (Table 1).

Turbidity in the river could limit the entry of sunlight into the water hence the concentration of dissolved oxygen (DO) was getting lower. The values of turbidity were 4.4-14.3 NTU. Naborsahan River could tolerate due to several genera exist in the entire station. The C-organic substrate was at each site range 2.36-2.72%. Location 3 was part of the downstream Naborsahan River, but C-organic content at the station 3 was lower than the position 2 (2.38%). This condition was because of the number of water hyacinth plants that grow on the station 3. The location that has lots of water hyacinth plants can absorb organic material so that the C-organic matter content is low [4].

The values of pH <5 or > 9 were incompatible for life of macrozoobenthos [5]. The results obtained by measuring the pH ranged 6-7. Based on the results of the measurement of pH in the habitat Naborsahan river still was suitable for the macrozoobenthos growth. According to the value of the DO was 3 mg/l, it was the minimum threshold value. The content of DO obtained ranged from 6.9 to 10.9mg/ l. The DO was the highest at the station three because the location 3 was an inlet of Lake

Toba and the lower reaches of the river to meet the Naborsahan waves and currents velocity caused the dissolved oxygen (DO) to be increased in the station. The BOD_5 was obtained for the entire sites *ex-situ* were equal to 1.8 to 7.1 mg/l. The different values in each research station were due to the difference amount of organic matter contained. Natural materials derived from domestic waste and agriculture which located on the Naborsahan river.

Table 1. Physical and chemical parameters of Naborsahan Rivers

Parameter	Station		
	1	2	3
Temperature (^oC)	23	23	25
Current velocity (m/s)	0.44	0.23	0.43
Depth (cm)	55.05	68.40	68.90
Brightness (cm)	49.30	50.40	55.90
Turbidity (NTU)	4.45	7.63	14.30
C-organic content (%)	2.36	2.72	2.38
pH	7.02	6.70	7.05
DO (mg/l)	6.90	7.20	10.90
BOD_5 (mg/l)	1.80	4.10	7.10
COD (mg/l)	5.56	5.70	5.75

DO: dissolved oxygen, BOD_5: biological oxygen demand, COD: chemical oxygen demand.
Data are the mean of quintuplicate analyses

3.2. Genus and distribution of macrozoobenthos

Table 2 displays distribution macrozoobenthos genera in Naborsahan River. At all stations, 26 genera were found. Almost every point sampled Thiara dominated throughout stations. Not all macro-zoobenthos had an excellent tolerance to environmental changes such as changes in physical and chemical parameters which differ in each site. There were several genera that there were only at the station two such as Bezzia and there were only at the location 3 such as Anentome, Alasmidonta, Gillia, Gyraulus, Hydrophilus, Littoridinops, Planaria, Prostoma, Pseudosuccinea, Somatogyrus, and Uvarus.

Relative abundance of each station showed the number of genera was divided by the total number of individuals. Table 3 depicted the relative abundance of the highest value was 99.96% at the station 2. Genus Stenelmis had the highest relative abundance value by 25% at the station 2, and the genus that had the lowest value relative abundance at this station was Bezzia, Chaoborus, Elimia, and Subulina with 0.62%. It has been reported that a habitat corresponded to the development of an organism if the value of relative abundance was more than 10% [6]. We interpreted that habitat at station II according to the development of Stenelmis because the levels of dissolved oxygen (DO) at position II was 7.2 mg/l and station I has the lowest level of turbidity 4.45 NTU (Table 1).

Table 3 showed the highest dominance index value was 0.31 at the location 3. By contrast, the stations 1 and 2 had dominance index values were 0.13 and 0.11, respectively. This study revealed that no specific macrozoobenthos genus dominant at every position due to dominance index value was under 0.5, indicating no particular genera that dominated of macrozoobenthos at each station.

Table 2. Genus and distribution of macrozoobenthos at the Naborsahan River

No	Genera	Station 1				Station 2				Station 3			
		1	2	3	4	1	2	3	4	1	2	3	4
1	Alasmidonta	-	-	-	-	-	-	-	-	-	-	+	+
2	Anentome	-	-	-	-	-	-	-	-	-	-	+	+
3	Bezzia	-	-	-	-	-	-	-	+	-	-	-	-
4	Branchiura	-	-	+	-	+	+	+	-	+	+	+	+
5	Chaoborus	-	-	+	-	+	-	-	-	-	-	-	-
6	Chrysops	-	-	-	-	+	-	+	+	-	-	-	-
7	Diamesa	-	+	+	-	+	-	-	+	-	-	-	-
8	Elimia	-	-	-	-	-	-	+	-	+	+	+	+
9	Gillia	-	-	-	-	-	-	-	-	+	+	+	-
10	Gyraulus	-	-	-	-	-	-	-	-	-	+	-	-
11	Hexatoma	-	+	+	+	-	+	+	+	-	-	-	-
12	Hydrophilus	-	-	-	-	-	-	-	-	-	-	+	-
13	Littoridinops	-	-	-	-	-	-	-	-	+	+	+	-
14	Melanoides	+	-	+	-	+	-	+	+	+	+	+	+
15	Physa	-	-	-	-	-	-	-	-	+	+	+	-
16	Pila	+	-	+	-	+	+	-	+	+	+	+	-
17	Planaria	-	-	-	-	-	-	-	-	+	-	-	-
18	Prostoma	-	-	-	-	-	-	-	-	+	-	-	-
19	Pseudosuccinea	-	-	-	-	-	-	-	-	-	-	+	-
20	Somatogyrus	-	-	-	-	-	-	-	-	-	+	-	-
21	Stenelmis	-	+	-	-	-	+	-	-	+	-	-	-
22	Subulina	-	-	-	-	-	-	+	-	-	+	-	-
23	Thiara	+	+	+	-	+	+	+	+	+	+	+	+
24	Tryonia	+	+	-	-	+	+	+	-	+	+	+	+
25	Uvarus	-	-	-	-	-	-	-	-	+	-	-	-
26	Viviparus	-	+	-	-	+	+	+	-	-	+	+	-

Note :
"Number 1-4" : The time of samples are taken once in two week
"+" : Presence of genus; "–" : Absence of genus;

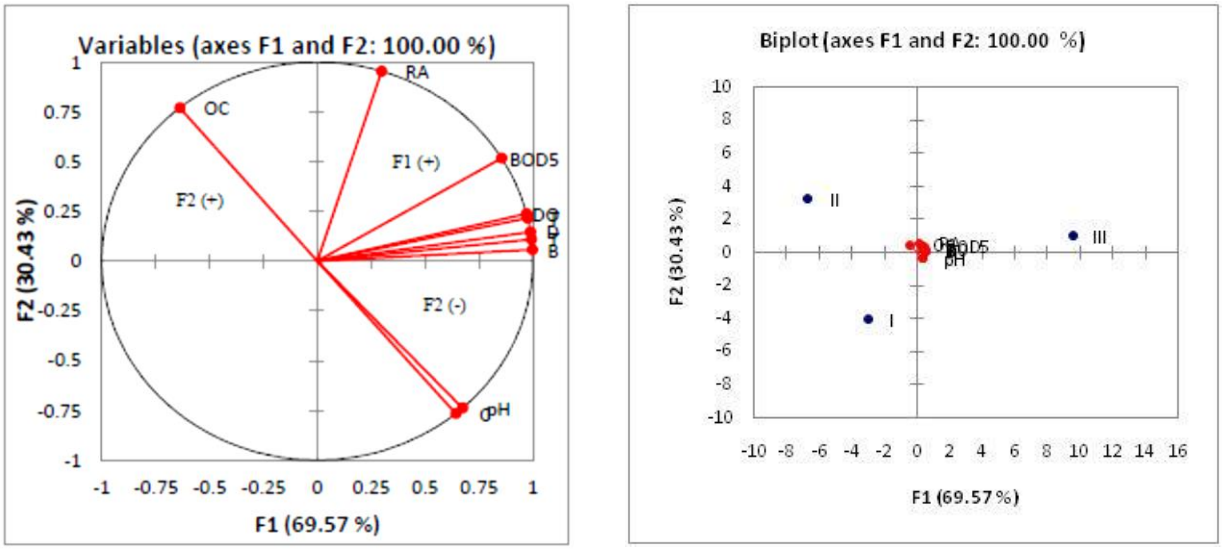
Table 3. Relative abundance (RA), dominance index (DI), dan equitability index (EI) of macrozoobenthos

Biological parameters	Station		
	1	2	3
Relative abundance	88.52	99.96	99.92
Dominance index	0.11	0.13	0.31
Equitability index	0.94	0.82	0.52

Data are the mean of quintuplicate analyses

Table 3 displayed the station 1 had the highest equitability index. The value of equitability index closed to 1 then the spread of the same number of each genus and value of equitability index closed to 0 then the number was not the same deployment [8]. The range of the large of each genus macrozoobenthos was around the same station. Therefore it has shown that an area has a number of the same genus to another area then the area has a higher diversity. Macrozoobenthos habitat characteristics could be determined through physical and chemical parameters contained in

macrozoobenthos habitat itself. Physical and chemical parameters would interact and influence each other so that the natural and artificial conditions would affect the status of macrozoobenthos [9].



(a) (b)

Note:
a. F1(+): brightness (B), turbidity (Tr), depth (D), temperature (T), DO, BOD_5 and relative abundance (RA). F2(+): C-organic content (OC), F2(-): C- organic content and pH.
b. All physical and chemical parameters were clustered at the three stations.

Figure 1. a. PCA variables with physical and chemical parameters and relative abundance.
b. PCA Biplot with physical and chemical parameters and relative abundance at the research station.

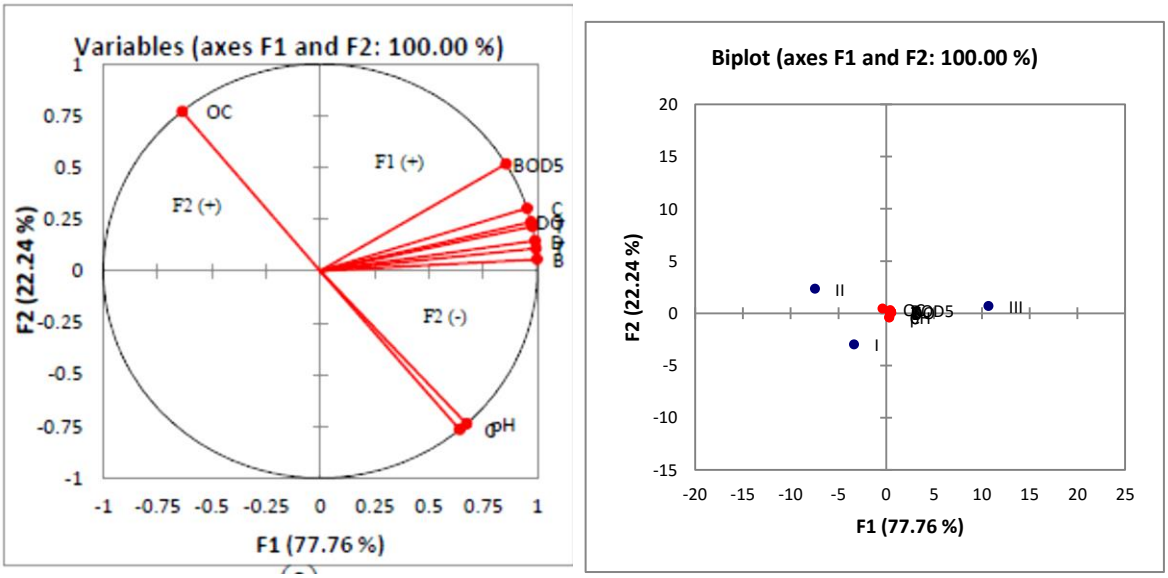
Figure 1a showed the positive axis 1 (F1) had the characteristics of habitat could be interpreted that the correlation circles tend to cluster called brightness, turbidity, depth, temperature, DO and BOD_5. The relative abundance found on the same axis with intensity parameters, such as turbidity, depth, temperature, DO, and BOD_5, as clumped, approached the X axis. These parameters have been shown to have a considerable effect on the relative abundance of macrozoobenthos. On the other hand, other parameters such as flow, pH, and C-organic content were no correlation to RA.

Figure 2a illustrated the results of the analysis were represented using two principal axes that would account for 100% of the total variance. Data consists of the main components of 77.76% and 22.24% for the second element, respectively. The interpretation of PCA had been considered to represent a state that occurs without reducing the information from the data obtained [10].

Habitat characteristics are shown in the positive axis one clearly that contributed these parameters negatively to the shaft 2. Dominance index was on the same axis with brightness parameters, turbidity, depth, temperature, DO and BOD_5. The six parameters have an important role to the dominance index of macrozoobenthos. While other parameters such as the current, pH, and C-organic content were not correlated to the index due to the dominance index from the X axis.

Dominance index value was under 0,5 (Table 1) showed all macrozoobenthos had the adaptability and survival rate difference at every station on the physical and chemical parameters to characterize the habitat of each site [6]. To conserve the habitat characteristics of macrozoobenthos an ecological approach was required at Naborsahan River accordingly.

The measurements of physical and chemical parameters associated with equitability index using PCA analysis to determine the characteristics of macrozoobenthos habitat. Some parameters such as depth, brightness, turbidity, DO, and BOD_5 significantly affected the results of the study which are represented by two principal components they were a major part (76.43%) and the second element (23.57%). The result showed that almost all parameters strongly influenced the station 3. PCA analysis was presented in Figure 3a and 3b.



(a) (b)

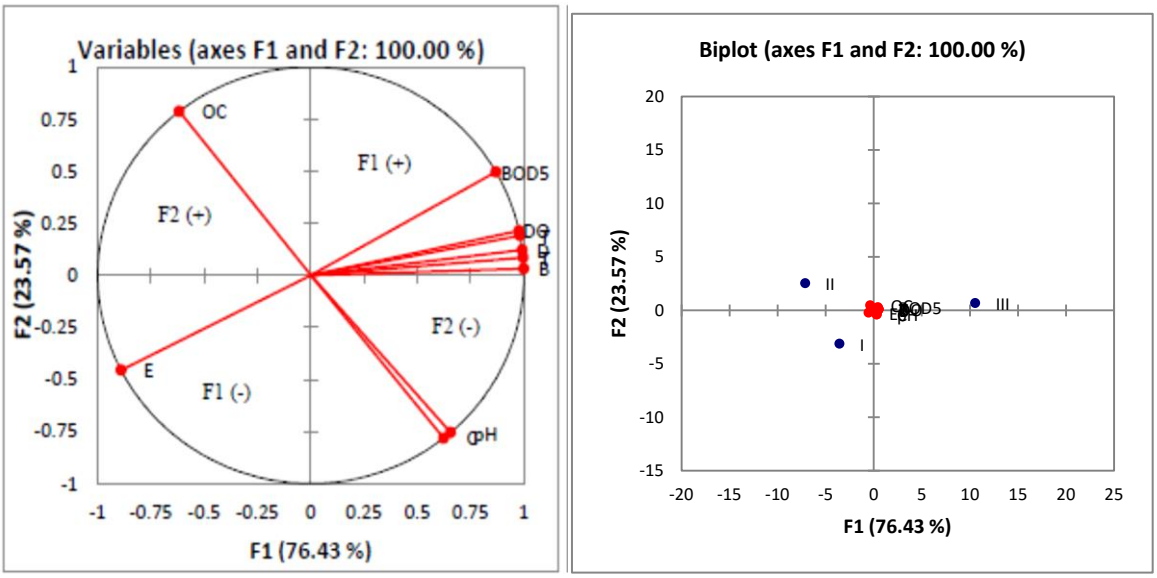
Note:

a. F1(+): Brightness (B), turbidity (Tr), depth (D), temperature (T), DO, BOD_5 and dominance index (DI). F2(+): C-organic content (KC), F2(-): current velocity (C) and pH.
b. All physical and chemical parameters were clustered at the three stations.

Figure 2. a. PCA variables with physical and chemical parameters and dominance index,
b. PCA Biplot with physical and chemical parameters and dominance index at three research stations.

Figure 3a shows habitat characteristics could be illustrated that the correlation circle was at negative axis 2. Parameters such as brightness, turbidity, depth, temperature, DO and BOD_5 and equitability index or was clustered index uniformity approaching the X axis. Our current results had a considerable influence on the equitability index macrozoobenthos. While the flow, pH, and C-organic content showed no correlation to the abundance of individuals that not be approaching the X axis.

Figure 3b depicts PCA analysis of physical and chemical parameters of the research site. The results displayed the physical and chemical parameters had a significant role and an essential habitat for macrozoobenthos at the station three that was on the negative axis 2. The station 3 was the lowest equitability index macrozoobenthos (0.52). The physical parameters of the PCA analysis affected the chemical characteristics of the habitat at the station three which showed smaller value indicates uniformity low. This result showed that the density of each type could be same and tend to be dominated by a particular type.



(a) (b)

Note:
a. F1 (+): Brightness (B), turbidity (Tr), depth (D), temperature (T), DO and BOD_5. F1 (-): Equitability index (E). F2 (+): C-organic substrate (OC). F2 (-): current velocity (C) and pH.
b. All physical and chemical parameters were clustered at the three station.

Figure 3. a. PCA variables with physical and chemical parameters and equitability index.
b. PCA Biplot with physical and chemical parameters and equitability index at the research station.

4. Conclusion

We have confirmed that physical and chemical parameters affected macro-zoobenthos habitat characteristics at each station. Six parameters play a significant role in Naborsahan river of Toba Samosir namely brightness, turbidity, depth, temperature, DO and BOD_5. The six parameters should be preserved to support the survival of macrozoobenthos in the sites.

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