Study on macrozoobenthos diversity in Batang Toru River and its surrounding, North Sumatra, Indonesia

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Abstract. Batang Toru River is one of the sizable rivers in North Sumatra, encompassing to south and west and stream down to the Indian Ocean. The river area has been used by the local community for several activities, i.e. fisheries and tourism. The macrozoobenthic community structure study was carried out for 3 months in April, July, and October 2019 at 13-17 stations from the upstream to the estuary. Observations were made on the type of macrozoobenthos, meanwhile, data analysis was performed on density, diversity index, evenness index, and dominance index. A total of 21 genera of macrozoobenthos was identified consists of 9 classes, namely Bivalvia (2 genera), Diptera (3 genera), Gastropoda (4 genera), Ephemeroptera (1 genus), Odonata (1 genus), Oligochaeta (6 genera), Plecoptera (1 genus), Tricoptera (2 genera), and Zygoptera (1 genus). Thiaria sp. and Balanocochlis sp. were quite commonly found in the study area. The density of the macrozoobenthos during the study period varied between 11-957 ind/m². The value of the diversity index, evenness index, and dominance index at each station varied from 0.722 to 2.419, 0.411 to 1.0, and 0.210 to 1.0, respectively. Based on these values, the condition of the Batang Toru river ecosystem expressed moderate ecological pressure.

Keywords: Batang Toru River; diversity; macrozoobenthos

1. Introduction
Batang Toru River is one of the major rivers in Sumatra with a length of 69.32 km. This river is surrounded by forest areas with an area of 136,000 ha spread over 3 regions, namely North Tapanuli, Central Tapanuli, and South Tapanuli Regencies. Currently, the forest in the Batang Toru area has been converted into production forest and arable land (81%), and only 19% is used as protection forest [1]. the consequence of excessive forest usage is that it can reduce the quantity and quality of water from Batang Toru River.
Efforts to analyze the relationship between the use of forest areas and dynamic water conditions such as the Batang Toru River are by analyzing the physical, chemical, and biological parameters of water. From the three methods, analysis of aquatic biology parameters can generally be closer to the original conditions. This is because the physical and chemical conditions of the water do not provide an overview of the quality of the water because the range of variable values is strongly influenced by the momentary situation [2].

Biota which is commonly used as an indicator of water quality is benthos. Benthos are animals that live on the bottom of the waters with limited movement or live permanently (sessile) and have varying adaptations to environmental conditions, making them ideal as indicators of water quality [3]. Benthos also has a wide distribution, occupies an important position in the food chain, and has a fast response compared with other higher organisms, so it can be used as an indicator of environmental pollution [4-6].

Some previous studies revealed that macrozoobenthos play an important role as an indicator of river water quality, namely diversity of gastropods in the mangrove ecosystem of the western coast of Aceh Besar District, Indonesia [7], crustacean biodiversity (Decapoda, Brachyura, Macrura) from the Kendari water expedition [3], macrozoobenthos as a biological indicator in determining water quality in the Suhuyon River, North Sulawesi [8]. Until now, no one has conveyed any information regarding benthos in the Batang Toru River. Based on this information, research on the diversity of benthic organisms to determine the status of the Batang Toru River ecosystem is needed. The result of this study will be essential as a basis data for better Batang Toru River management.

2. Material and methods

2.1. Time and location
This research was conducted in April-October 2019 in Batang Toru River at 13-17 research stations figure 1. Station 1 (1A = Waters in Batu Mundom Village; 1B = Batang Toru River near the estuary; 1C = Rawa Muara Opu) represents the downstream area of the Batang Toru River. Stations 2 and 3 (2A = Sungai Batang Toru in Bandar Tarutung Village; 2B = Mabang Pasir; 2C = Lake Siais; 3A = Batang Toru at Trikora Bridge; 3B = Sungai Parsaliran; 3C = Batang Toru River near the estuary of the Parsaliran River) represents middle area. Stations 4 and 5 (4A = Sitandiang River; 4B = Sitandiang River Estuary; 4C = Batang Payah River; 4D = Malakut River; 4E = Malakut River estuary; 4F = Aek Sikkut; 4G = Aek Toras; 4H = Sigumuruh River; 5A = The Batang Toru River in Huta Imbaru) represents the upstream area.

2.2. Sampling
Determination of sample locations using purposive sampling. Macrozoobenthos sampling was carried out by using grab and surber with 3 replications at each research station. Several parameters of the aquatic environment were also observed, including water temperature, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), pH, and turbidity. Identification of benthic organism was performed to the lowest possible taxon by using the Collecting Shells book [9].

2.3. Data analysis
The parameters analyzed include the calculation of density, the diversity index (\( H' \)), evenness index (E), and dominance index (C) as follows [10]:

a. Density (K) = Number of individuals/area of all sample plots

b. Shannon–Wiener Diversity Index (\( H' \)), as follows:

\[
H' = \sum P_i \log P_i
\]
\[ P_i = \frac{n_i}{N} \]  

Information:
- \( P_i \) = Abundance index
- \( n_i \) = number of individuals per species
- \( N \) = total number of species (ind)

c. Evenness index (E) is as follows:

\[ E = \frac{H'}{\log S} \]  

Information:
- \( E \) = Evenness index
- \( H' \) = Shannon–Wiener Diversity Index
- \( S \) = Number of species

d. Simpson's Dominance Index (C) is as follows:

\[ C = \sum P_i^2 \]  
\[ P_i = \frac{n_i}{N} \]  

Information:
- \( D \) = Simpson's dominance index
- \( n_i \) = Number of individuals of a type
- \( N \) = Number of individuals of all types (ind)

All the data are presented in figures and tables then analyzed descriptively by comparing them with related studies.
Figure 1. Sampling locations for research activities in Sungai Batang Toru and its surroundings, North Sumatra.
3. Results and discussion

3.1. Results

3.1.1. Diversity and density. Based on observations made in April, July, and October 2019, identification and calculation of macrozoobenthos from all observation stations in the waters of the Batang Toru River and its surroundings are presented in table 1.

Table 1. The average abundance of macrozoobenthos in Batang Toru River during the study period.

| Organism          | Average (ind/m²) |
|-------------------|------------------|
|                   | April | July | October |
| **BIVALVIA**      |        |      |         |
| Anodonta sp.      | 2.1   |      |         |
| Corbicula sp.     | 6.2   |      |         |
| **DIPTERA**       |        |      |         |
| Chironomus sp.    | 5.5   | 29.0 |         |
| Simulium sp.      | 1.6   | 8.3  |         |
| Tanytarsus sp.    | 2.4   | 6.2  |         |
| **EPHEMEROPTERA** |        |      |         |
| Ephemerella sp.   | 0.8   | 2.4  |         |
| **GASTROPoda**    |        |      |         |
| Balanocochlis sp. | 37.3  | 2.1  |         |
| Melanoïdes sp.    | 4.5   | 18.6 |         |
| Septaria sp.      | 2.1   |      |         |
| Thiara sp.        | 14.5  | 43.5 |         |
| **ODONATA**       |        |      |         |
| Aeshna sp.        | 3.9   |      |         |
| **OLIGOCHAETA**   |        |      |         |
| Aeolosoma sp.     | 4.1   | 10.4 |         |
| Cambarincola sp.  | 2.2   |      |         |
| Lumbriculus sp.   | 4.5   | 2.9  |         |
| Nais sp.          | 16.5  | 14.3 | 20.7    |
| Tubifex sp.       | 2.1   |      |         |
| Pristina sp.      | 0.8   |      |         |
| **PLECOPTERA**    |        |      |         |
| Acroneuria sp.    | 7.9   |      |         |
| **TRICHOPTERA**   |        |      |         |
| Hydropsyche sp.   | 4.1   |      |         |
| Philopotamus sp.  | 0.8   | 8.3  |         |
| **ZYGOPTERA**     |        |      |         |
| Argia sp.         | 5.5   |      |         |

Base on table 1, the macrozoobenthos classes are divided into 9 classes, namely Bivalvia, Diptera, Ephemeroptera, Gastropoda, Odonata, Oligochaeta, Plecoptera, Trichoptera, and Zygoptera. In terms of time observation, 3 classes of macrozoobenthos were recorded in April, 8 classes in July, and 5 classes of macrozoobenthos were collected in October. Macrozoobenthos density varied from 0.8 to 16.5 ind/m² (April), 0.8-37.3 ind/m² (July), and 2.1- 43.5 ind/m² (October). Abundance of Thiara sp. higher than abundance of Ephemerella sp., Pristina sp., and Philopotamus sp. larvae were collected during the study period.
3.1.2 Taxa and density of macrozoobenthos. Analysis of the taxa and the abundance of macrozoobenthos in the Batang Toru river showed that the macrozoobenthos in the Batang Toru river were available at three observation times (table 2).

Table 2. The number of taxa and abundance of macrozoobenthos at each sampling station during the study period.

| Station | Total Taxa | abundance (ind/m²) |
|---------|------------|--------------------|
|         | April      | July | October | October *) | April | July | October | October *) |
| 1A      | -          | 2    | 4       | -          | 232   | 957  | -       | -          |
| 1B      | 3          | 3    | 5       | -          | 116   | 87   | 754     | -          |
| 1C      | -          | -    | 2       | -          | -     | 58   | -       | -          |
| 2A      | 1          | 4    | 3       | -          | 29    | 812  | 145     | -          |
| 2B      | 0          | 0    | 0       | -          | 0     | 0    | 0       | -          |
| 2C      | 0          | 2    | 1       | -          | 0     | 116  | 29      | -          |
| 3A      | 2          | 6    | 5       | -          | 87    | 143  | 232     | -          |
| 3B      | 0          | 1    | 2       | 5          | 0     | 11   | 58      | 110        |
| 3C      | 0          | 3    | 6       | -          | 0     | 88   | 261     | -          |
| 4A      | 1          | 4    | 2       | 2          | 11    | 77   | 145     | 33         |
| 4B      | 2          | 4    | 2       | 4          | 22    | 55   | 58      | 88         |
| 4C      | 1          | 3    | 2       | 3          | 29    | 55   | 116     | 44         |
| 4D      | 1          | 2    | 2       | 4          | 29    | 33   | 58      | 88         |
| 4E      | 2          | 1    | 5       | 7          | 58    | 11   | 203     | 242        |
| 4F      | -          | -    | -       | -          | -     | -    | -       | -          |
| 4G      | -          | -    | 4       | 5          | -     | 261  | 66      | -          |
| 4H      | -          | -    | 3       | 5          | -     | 116  | 66      | -          |
| 5A      | 0          | 1    | 0       | 2          | 0     | 11   | 0       | 88         |

Information: 1A = Waters in Batu Mundom Village; 1B = Batang Toru River near the estuary; 1C = Muara Opu Swamp; 2A = Batang Toru River (in Bandar Tarutung Village); 2B = Batang Toru River (Mabang Pasir); 2C = Lake Siais; 3A = Batang Toru (on the Trikora Bridge); 3B = Parsaliran River; 3C = Batang Toru River (near the estuary of the Parsaliran River); 4A = Sinandiang River; 4B = Estuary of the Sinandiang River; 4C = Batang Payah River; 4D = Malakut River; 4E = mouth of the Malakut River; 4F = Aek Sikkut; 4G = Aek Toras; 4H = Sigumuruh River; 5A = Batang Toru River in Huta Imbaru. *) = retrieval using surber.

Based on table 2, the number of macrozoobenthos taxa based on the stations observed in April varies between 1-3 species, 1-6 species in July, and 1-6 species in October. At some stations, macrozoobenthos was not found. In April, a small number of taxa was found at several stations (2A, 4A, 4C, 4D), while a large number of taxa was found at station 1B (near the mouth of the Batang Toru River). In July, a small number of taxa were found at stations 3B, 4E, and 5A; while a few numbers of macrozoobenthos were found at station 3A (Trikora Bridge). In October, a small number of taxa was found at station 2C (Lake Siais), while many species of macrozoobenthos were collected at station 3C (estuary of the Parsaliran River).

Macrozoobenthos density at each sampling location varies from 11-116 ind/m² (April), 11-812 ind/m² (July), and 29-957 ind/m² (October). In April, a slight density of macrozoobenthos was found at station 4A, while a quite large was found at station 1B (near the mouth of the Batang Toru River). In July, small densities of macrozoobenthos were recorded at station 3B (Parsaliran River), 4E (mouth of the Malakut River), and 5A (Batang Toru River in Huta Imbaru), while a plenty amount of macrozoobenthos density was found at station 2A (Bandar Tarutung). In October, a small density was found at station 2C (Lake Siais), while a fairly large density was found at station 1A (mouth of the Batang Toru River).
3.1.3. Diversity, evenness, and dominance index. The concept of community can describe the condition of an ecosystem. Stable ecosystems can be characterized by high biodiversity. The values of diversity index (H’), evenness index (E), and dominance index (D) for macrozoobenthos in the Batang Toru River and its surroundings are presented in table 3.

Table 3. Diversity index (H’), evenness index (E), and dominance index (D) of macrozoobenthos in Batang Toru River during the study period.

| Station | Diversity Index | Evenness Index | Dominance Index |
|---------|-----------------|----------------|-----------------|
|         | A               | J              | O   | O * | A   | J  | O  | O * | A   | J  | O  | O * |
| 1A      | -               | 0.811          | 0.821| 0.811| 0.411| -  | -  | -  | 0.625| 0.730| -  |
| 1B      | 1.500           | 1.585          | 1.537| 0.946| 1.000| 0.662| -  | 0.375| 0.333| 0.467| -  |
| 4A      | 0.722           | 0.918          | 0.918| 0.921| 0.722| 0.918| 1.000| 0.306| 0.680| 0.556| -  |
| 4B      | 1.000           | 1.922          | 1.000| 1.000| 0.961| 1.000| 0.500| 0.28  | 0.500| -  |
| 4C      | 0.000           | 1.371          | 0.811| 1.500| 0.865| 0.811| 0.946| 1.000| 0.44  | 0.625| 0.375|
| 4D      | 0.000           | 0.918          | 1.000| 0.000| 0.918| 1.000| 1.000| 0.556| 0.500| -  |
| 4E      | 1.000           | 0.000          | 2.128| 1.000| 0.917| -  | 0.500| 0.265| -  |
| 4F      | -               | -              | -    | -    | -    | -  | -  | -  | -  |
| 4G      | -               | 1.753          | 2.252| -    | 0.876| 0.970| -  | 0.330| 0.375| -  |
| 4H      | -               | 1.500          | 2.252| -    | 0.946| 0.970| -  | 0.375| 0.222| -  |
| 5A      | 0.000           | 0.000          | 0.811| 0.000| 0.000| 0.811| 0.000| 0.625| -  |

Information: A (April), J (July), O (October), O * (October *). 1A = Waters in Batu Mundum Village; 1B = Batang Toru River near the estuary; 1C = Muara Opu Swamp; 2A = Batang Toru River (in Bandar Tarutung Village); 2B = Batang Toru River (Mabang Pasir); 2C = Lake Siais; 3A = Batang Toru (on the Trikora Bridge); 3B = Parsaliran River; 3C = Batang Toru River (near the estuary of the Pasaliran River); 4A = Sitandiang River; 4B = Estuary of the Sitandiang River; 4C = Batang Payah River; 4D = Malakut River; 4E = mouth of the Malakut River; 4F = Aek Sikkut; 4G = Aek Toras; 4H = Sigumuruh River; 5A = Batang Toru River in Huta Imbaru. *) = retrieval using surber.

Based on table 3, it is known that the macrozoobenthos diversity index (H’), varied from 0.918 to 1.500 (April), 0.918-2.316 (July), and 0.811-2.419 (October). In April, a small diversity index was found at several stations, while a fairly high diversity index was found at station 1B (near the mouth of the Batang Toru River). In July, a low diversity index was found at several stations, and a high diversity was found at station 3A (Trikora Bridge). In October, a low diversity index was recorded at several stations, and a high diversity index was found at station 3C (estuary of the Pasaliran River). The value of the diversity index (H’) ranged from 0.811-2.419 indicates that all observation locations have a low to medium diversity category.

The evenness index varied from 0 to 1 during the study period. In April, a low evenness index value was found at several stations, while a fairly high evenness index was found at station 4B (estuary), 4A (Sitandiang River), and 4E (mouth of the Malakut River). In July, low evenness index values were found at station 2B (Batang Toru river (Mabang Pasir)), 3B (Parsaliran River), and 4E (mouth of the Malakut River), and the highest evenness index was found at station 1B (the mouth of the Batang Toru River). In October, low evenness index values were found at station 2B (Batang Toru river (Mabang Pasir)), 2C (Lake Siais), and 5A (Batang Toru river in Huta Imbaru), and the highest was found at station 1C (Muara
Opu Swamp). The values of the evenness index ranges from 0-1 indicate the low to high evenness category.

The dominance index (D) of macrozoobenthos varies from 0 to 1 in all sampling times. In April, low dominance index values were found at several stations, and high dominance index values were also found at several stations i.e., 2A (Batang Toru River (in Bandar Tarutung Village)), 4A (Sitandiang River), 4C (Batang Payah River), 4D (Malakut River). In July, a low dominance index value was found at station 2B (Mabang Pasir), and high values were found at station 3B (Sungai Parsilaran), 4E (mouth of the Malakut River), and 5A (Huta Imbaru). Meanwhile, in October, a low dominance index was found at station 2B (Mabang Pasir) and 5A (Huta Imbaru), while a sizable index of dominance was found at station 2C (Lake Siais). D values ranging from 0-1 indicate the presence of low to high dominance.

In October, macrozoobenthos sampling was also carried out using surber. The results of the observations are also presented in Table 3. The diversity index ranged from 0.811-2.252, the evenness index ranged from 0.811-1.000 and the dominance index ranged from 0.222-0.645. From the ecological index values, it can be concluded that diversity is classified as low-medium, fairly high diversity, and low to moderate dominance.

3.2. Discussion

Macrozoobenthos is an aquatic organism that lives on the bottom of the waters, is quite easy to obtain, has various types, and is sensitive to different types of pollutants [11]. This biota is also a good indicator for estimating habitat conditions in water [12]. Based on observations, Gastropod was the most abundant taxa of macrozoobenthos with a density of 4.5 ind/m² (April), 2.1-37.3 ind/m² (July), and 2.1-43.5 ind/m² (October). Thiara sp. was the most abundant macrozoobenthos in October. Meanwhile, Balanocochlis sp. was a macrozoobenthos from the Gastropod Class with the highest density in July. This finding is in line with the previous research [13], which states that macrozoobenthos from the Gastropoda Class is a type of macrozoobenthos that is commonly found in rivers. Other than that, stated that the macrozoobenthic community in the river was dominated by the mollusca group [14]. Research at the estuary of the Cimandiri River also found that the species of Class Gastropod was a dominant species of macrozoobenthos community [15]. This shows that Gastropods have fairly wide adaptability and tolerance range to environmental conditions. Gastropods have fairly high adaptability and wide tolerance to different water conditions and seasons [16-18].

The average diversity index values obtained ranged from 0.918-1.500 (April), 0.811-2.316 (July), and 0.811-2.419 (October). Almost every station has a diversity index value of <2, only stations 3A, 3C, and 4E (October 2019) have a value of >3. The lowest diversity index value was observed in April while compared with diversity indexes in July and October. This can be caused by the rainy season which has occurred since January.

The macrozoobenthos evenness values in the Batang Toru River and its surroundings were quite high. The dominance index values varied from 0.000-1.00 (April), 0.000-1.00 (July) and 0.000-1.00 (October). This value indicates that there were no dominant species. Thus, the condition of the Batang Toru River ecosystem has moderate diversity with moderate ecological pressure and does not occur dominance by either genus. This can indicate that the condition of the waters in the Batang Toru River and its surroundings is still relatively good.

In general, the diversity index at stations near the upstream (station 4, 5) is lower than the stations in the middle area (station 2, 3) and downstream area (station 1). The differences in diversity index was caused by differences in location. Stations 1, 2, and 3 are in river flow, so the organic matter content is low, but the TSS and turbidity values are high. In water with high TSS values, organisms that ate the suspended particles were replaced by organisms that ate the deposited particles. This is due to the disruption of the function of the filtering system, vision, and respiration [19, 20]. This is also thought to be causing the diversity of biota in the locale to be low.

A high evenness index value (close to 1) indicates that the community is in a relatively stable condition and there is no instability of environmental factors [21]. The lowest evenness index values are found at stations 1, 2, 3 and fairly high evenness values are found at stations 4 and 5 because at these
stations only a few types of organisms were found. The low evenness index value is influenced by the number of species and the number of individuals within the species.

In general, the dominance index value ranging from 0 to 1. The dominance index value is close to 1 indicating that a certain type of macrozoobenthos is dominant in the community [22]. Makrozoobenthos which dominates the station was *Thiara* sp. and *Balanocochlis* sp. from the Mollusc group. According to research in the western part of Segara Anakan obtained the dominant macrozoobenthos from the Mollusc group [23], in the Donan river [14], coastal waters by Tangerang also obtained the same result [24]. This shows that mollusks have a wide adaptability and tolerance range to environmental changes, that the Class Mollusca is resistant to increasing erosion and unfavorable conditions [19][25][26]. Macrozoobenthos which can adapt will show an increase in species density while other species will experience a decrease in density.

In this study, 21 genera of macrozoobenthos were collected from Batang Toru River. The number of macrozoobenthos in Batang Toru was higher than the research results in Sungai Rombok (West Kalimantan) which had 11 genera [27], research in the Sangatta River (East Kalimantan) with 4 genera [28]. Jeneberang (South Sulawesi) represents by 18 genera [29], Kumpeh River (Jambi) with 8 genera [30], Keyang River (East Java) had 14 genera [31], Lematag River (South Sumatra) with 11 genera [32]. However, the genera number of macrozoobenthos in the Batang Toru River and its surroundings was less than in the Damar River (Central Java), with 27 genera [33].

In the Batang Toru River, the most common macrozoobenthos with high abundance is the Mollusca group. Rivers with rocky substrates generally have more species of mollusca [27]. Another researcher also reported that mollusca was commonly found with great numbers in Sangatta River, East Kalimantan [28]. From this comparison, it is known that the types of macrozoobenthos and their habitats are very varied, some of the species may be found in a different location, but the numbers are different. The differences in the results also depend on the size of the study area and the number of sampling stations. In a narrow area with a short time study period, it will also produce less macrozoobenthos compared with wider coverage and more time or frequency of sampling.

4. Conclusion
The macrozoobenthos found in Batang Toru River consisted of 9 classes namely Bivalvia, Diptera, Ephemeroptera, Gastropoda, Odonata, Oligochaeta, Plecoptera, Trichoptera, and Zygoptera. Gastropoda was the most abundant macrozoobenthos in Batang Toru River during the study period. Besides, *Thiara* sp. and *Balanocochlis* sp. were the main constituent component of the macrozoobenthos community in Batang Toru River. Based on ecological indexes i.e. diversity index, evenness index, and dominance index, Batang Toru River ecosystem has moderate diversity with moderate ecological pressure.

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