Study on zooplankton diversity aquatic ecobiology of Batang Toru River, North Sumatera, Indonesia

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Abstract. The Batang Toru River is a fairly long river, flowing from the North Tapanuli region and emptying into the Indian Ocean (South Tapanuli Regency). Increased deforestation in the Batang Toru River area has increased the potential for decreasing water quality of the Batang Toru River. The purpose of this study was to determine the condition of the water quality of the Batang Toru River. This research was conducted for 3 months (April, July, October), in the Batang Toru River and its surroundings (14 observation stations scattered from the area near the upstream to the coast). The data analysis used in this research is the analysis of the abundance and composition of the types of phytoplankton, the Diversity Index (H'), the Evenness Index (E), and the Dominance Index (C). Based on the research results, zooplankton in these waters consist of Six Phylum of zooplankton, such as Ciliophora (4 genera), Amoebozoa (2 genera), Cercozoa (1 genera), Rotifera (9 genera), Arthropoda (3 genera), and Annelida (2 genera). Diversity, Evenness, and Dominance Indices were around 0.349 - 1.847, 0.503 - 0.994 and 0.240 - 0.802. Based on the index value, it can be concluded that the Batang Toru River is classified as experiencing moderate ecological pressure.

Keywords: Batang Toru River; community structure; zooplankton

1. Introduction
The Batang Toru River is one of the rivers in the North Sumatra region with a length of about 125 km, flowing from the North Tapanuli region and emptying into the Indian Ocean (South Tapanuli Regency). The Batang Toru River is the habitat for several fish including eel (Anguilla sp.), Wader fish (Osteochilus waandersii), and tor fish (Tor sp.). The potential of this fish resource will be threatened due to deforestation in the Batang Toru River area which is starting to increase which will damage the quality and quality of the Batang Toru River water [1].

Efforts to see the impact of deforestation on river water can use a bioindicator approach. One of the biota that can be used as an indicator is zooplankton. Zooplankton is a biota that has a very important
role in the food chain in an ecosystem. Zooplankton is the main key in the transfer of energy from major producers to consumers in the first level in tropical ecology. This is what causes zooplankton to be used as an indicator of water pollution [2].

Several research activities related to zooplankton in rivers were carried out by several researchers, including zooplankton in the Je'neberang River ecosystem (Kab. Goa) [3], S. Pepe (Central Java) [4], S. Majakerta (West Java) [5], S. Rungan Kota (Central Kalimantan) [6], S. Siak (Riau) [7], S. Serang (Yogyakarta) [8], Je'neberang Sungguminasa (Kab. Goa, South Sulawesi) [3], Mempawah River (West Kalimantan) [9], and Bengawan Solo River (Central Java) [10]. However, research related to zooplankton in the Batang Toru River and its surroundings (North Sumatra) has not been reported. Therefore, researchers conducted research activities regarding zooplankton in the region.

The purpose of this study was to analyze the zooplankton community structure in the Batang Toru River and its surrounding waters. This information is expected to become the basis of policy for river management activities, especially river fisheries.

2. Method

2.1. Time and location
The research was carried out in the waters of the Batang Toru River and its surroundings, North Sumatra (figure 1) for three months (April, July, October 2019) representing the rainy season, dry season, and transitional season between the two. Sampling was carried out to represent the three river segments - upstream, middle, and downstream.

The first observation was carried out representing the rainy season on April 2019, the second observation representing the transition season carried out in several stages, namely in July, the third observation was carried out in October 2019. Sampling activities were carried out at 13 research stations located on the Batang Toru River, and 1 station research on Lake Siais. The research location is presented in figure 1.

2.2. Technique sampling and analysis of zooplankton
Zooplankton sampling by filtering surface water using plankton net, filtered water as much as 500 liters (50 liters 10 times). Plankton identification [11] was carried out at the Laboratory of Ecobiology and Conservation of Aquatic Resources, Department of Aquatic Resource Management, Faculty of Fisheries and Marine Sciences IPB.

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 [12]:

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:
$H'$ = Shannon–Wiener Diversity
$P_i$ = Abundance index
$n_i$ = number of individuals per species
$N$ = total number of species (ind)


Figure 1. Sampling locations for research activities in the Batang Toru River and its surroundings, North Sumatra.

Note: 1A= Batu Mundom Village; 1B= Batang Toru near of mouth of river; 1C= Muara Opu swamp; 2A= Batang Toru River in Bandar Tarutung Village; 2B= Mabang Pasir; 2C= Siais Lake; 3A= Batang Toru near Trikora Bridge; 3B= Pasaliran River; 3C= Batang Toru River near mouth of river Pasaliran; 4A= Sitandiang River; 4B= Sitandiang mouth of river; 4C= Batang Payah River; 4D= Malakut River; 4E= Malakut Mouth of river; 4F= Aik Sikkut; 4G= Aik Toras; 4H= Sigumuruh River; 5A= Batang Toru River in Hutaimbaru.
c. Evenness index (E) is as follows:

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

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

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)

3. Result and Discussion

3.1. Result
3.1.1. Genus and abundance of zooplankton. The analysis results related to the genus and abundance of macrozoobenthos in the Batang Toru River are presented in table 1.

| Phylum      | Organism         | Average Abundance (ind./m³) |
|-------------|------------------|-----------------------------|
|             |                  | April | July | October |
| CILIOPHORA  | Spirostomum sp.  | 0     | 36   | 543     |
|             | Stentor sp.      |       | 71   |         |
|             | Tintinnidium sp. | 36    |      |         |
|             | Tintinnopsis sp. | 394   | 519  |         |
| AMOEBOZOA   | Arcella sp.      | 555   | 1396 | 495     |
|             | Diffugia sp.     | 555   | 895  | 330     |
| CERCOZOA    | Euglypha sp.     | 686   | 1002 |         |
|             | Asplanchna sp.   | 36    |      |         |
|             | Brachionus sp.   | 72    | 472  |         |
|             | Euchlanis sp.    |       |      | 47      |
|             | Keratella sp.    |       |      | 47      |
| ROTIFERA    | Lepadella sp.    | 107   | 47   |         |
|             | Monostylia sp.   | 36    | 94   |         |
|             | Mytilina sp.     | 36    | 24   |         |
|             | Notholca sp.     |       | 259  |         |
|             | Trichocerca sp.  | 36    | 377  |         |
|             | Larva Ostracoda  | 16    |      |         |
| ARTHROPODA  | Cyclops sp.      | 36    | 24   |         |
|             | Nauplius         | 62    | 72   | 472     |
| ANNELIDA    | Larva Annelida   | 16    |      |         |
|             | Larva Oligochaeta|       |      | 94      |

Based on table 1, it can be seen that there are 6 phylum zooplankton from all time and observation locations. The 6 phylum, among others Ciliophora, Amoebozoa, Cercozoa, Rotifera, Arthropoda, and Annelida. The highest abundance in April is *Euglypha* sp. with a value of 686 ind./m³. In July the highest
abundance is *Arcella* sp. With a value of 1396 ind./m$^3$, while in October the highest abundance was *Spirostomum* sp. with a value of 543 ind./m$^3$. Besides that, it is also known that in total Phylum Amoebozoa is the phylum with the highest abundance value with a value of 4226 ind./m$^3$, while the phylum with the lowest abundance is Phylum Annelida with a value of 110 ind./m$^3$.

### 3.1.2. Taxa and abundance of zooplankton

The results of the analysis related to taxa and the abundance of macrozoobenthos in the Batang Toru River are presented in table 2. Based on table 2, It can be seen that the number of zooplankton Taxa in the Batang Toru River varies with each location and time of observation. In April, the number of Taxa ranges from 2-5 Taxa, the highest Taxa is at location 2C (5 Taxa), while the lowest is at location 1C, 4G, and 4H (0 Taxa). In July, the number of Taxa ranges from 2-4 Taxa, the highest Taxa is at location 3A (4 Taxa), while the lowest number of taxa is at locations 1C, 4C, and 4H (0 taxa). In October the number of Taxa ranged from 1-8 Taxa, the highest Taxa was at location 5A (8 Taxa), and the lowest Taxa was at location 1C (1 Taxa).

**Table 2.** Taxa and abundance of zooplankton in April, July, and October.

| Station | Taxa Number | April | July | October | Abundance (ind./m$^3$) |
|---------|-------------|-------|------|---------|-----------------------|
|         |             |       |      |         |                       |
| 1A      | 3           | 3     | 7    | 1103    | 6012 7619            |
| 1B      | 2           | 4     |      | 8016    | 7218                 |
| 1C      | 1           |       |      | 1203    |                      |
| 2A      | 3           | 2     | 3    | 1605    | 6513 2005            |
| 2B      | 3           | 3     | 3    | 2104    | 10521 2005           |
| 2C      | 5           | 2     | 3    | 4511    | 2004 3208            |
| 3A      | 3           | 4     | 2    | 1704    | 3006 4812            |
| 3B      | 3           | 2     | 6    | 1404    | 3507 4010            |
| 3C      | 2           | 3     | 4    | 1303    | 1503 4010            |
| 4A      | 3           | 2     | 3    | 1303    | 4008 1604            |
| 4B      | 3           | 3     | 2    | 1303    | 3507 1604            |
| 4C      | 3           | 2     | 5    | 2105    | 1503 2807            |
| 4D      | 3           | 2     | 5    | 2005    | 2505 2807            |
| 4E      | 3           | 2     | 3    | 1905    | 1503 2005            |
| 4G      | 2           |       |      |         | 3609                 |
| 4H      | 6           |       |      |         | 6817                 |
| 5A      | 4           | 4     | 8    | 2206    | 4509 9223            |

Note: 1A= Batu Mundom Village; 1B= Batang Toru near of mouth of river; 1C= Muara Opu swamp; 2A= Batang Toru River in Bandar Tarutung Village; 2B= Mabang Pasir; 2C= Siais Lake; 3A= Batang Toru near Trikora Bridge; 3B= Pasaliran River; 3C= Batang Toru River near mouth of river Pasaliran; 4A= Sitandiang River; 4B= Sitandiang mouth of river; 4C= Batang Payah River; 4D= Malakut River; 4E= Malakut Mouth of river; 4F= Aik Sikkut; 4G= Aik Toras; 4H= Sigumuruh River; 5A= Batang Toru River in Hutaimbaru.

Besides the varying number of taxa, the abundance value of zooplankton in the Batang Toru River also varies with each location and time of observation. In April, the abundance of zooplankton was around 0-4511 ind./m$^3$, the highest abundance was at location 2C (4511 ind./m$^3$), while the lowest was at location 1C, 4G, and 4H (0 ind./m$^3$). In July, the abundance of zooplankton ranged from 0-10521 ind./m$^3$, the highest abundance was at location 2B (10521 ind./m$^3$), while the lowest abundance was at locations 1C, 4C, and 4H (0 ind./m$^3$). In October the abundance was around 1203-9223 ind./m$^3$, the highest abundance was at location 5A (9223 ind./m$^3$), and the lowest abundance was at location 1C (1203 ind./m$^3$).
3.1.3. Diversity, evenness and dominance index. The results of the calculation of Diversity, Evenness and Dominance Index of Zooplankton in Batang Toru River are presented in Table 3. In April 2019 observations, the diversity index value ($H'$) varied from 0.617 to 1.287, which indicates that all time observations have a low-medium diversity category. A small diversity index value was found at Station 3C, while a fairly large diversity index value was found at Station 5A. The Evenness index (E) of zooplankton in these observations varies between 0.685-0.994 which belongs to the medium-high evenness category for the entire observation time. A fairly small evenness index was found at Station 3A, and a fairly large uniformity index was found at Station 4C. Based on the results of observations for that month, the dominance index (D) varied between 0.293-0.574 which means low-medium. A small dominance index is found at Station 5A, while a fairly large dominance index was found at Station 3C.

| Station | Diversity Index | Evenness Index | Dominance Index |
|---------|-----------------|----------------|-----------------|
|         | April | July | October | April | July | October | April | July | October |
| 1A      | 1.09  | 1.078 | 1.649  | 0.992 | 0.981 | 0.847  | 0.339 | 0.347 | 0.247  |
| 1B      | 0.562 | 1.301 | 0.811  | 0.811 | 0.625 | 0.625  |
| 2A      | 0.975 | 0.950 | 0.887  | 0.969 | 0.865 | 0.407  | 0.220 | 0.44  |
| 2B      | 0.983 | 0.999 | 1.055  | 0.895 | 0.909 | 0.960  | 0.405 | 0.392 | 0.36   |
| 2C      | 1.269 | 0.562 | 1.082  | 0.788 | 0.811 | 0.985  | 0.338 | 0.625 | 0.344  |
| 3A      | 0.753 | 1.33  | 0.637  | 0.685 | 0.959 | 0.918  | 0.557 | 0.278 | 0.556  |
| 3B      | 0.83  | 0.683 | 1.609  | 0.756 | 0.985 | 0.898  | 0.506 | 0.51  | 0.24   |
| 3C      | 0.617 | 1.099 | 1.089  | 0.89  | 1     | 0.785  | 0.574 | 0.333 | 0.42   |
| 4A      | 1.012 | 0.377 | 1.040  | 0.921 | 0.544 | 0.946  | 0.385 | 0.781 | 0.375  |
| 4B      | 1.012 | 0.796 | 0.562  | 0.921 | 0.725 | 0.811  | 0.385 | 0.551 | 0.625  |
| 4C      | 1.092 | 0.637 | 1.550  | 0.994 | 0.918 | 0.963  | 0.338 | 0.556 | 0.224  |
| 4D      | 1.049 | 0.5   | 1.475  | 0.955 | 0.722 | 0.917  | 0.365 | 0.68  | 0.265  |
| 4E      | 1.013 | 0.631 | 1.055  | 0.922 | 0.918 | 0.960  | 0.385 | 0.556 | 0.360  |
| 4G      | 0.349 | 0.503 | 0.802  |
| 5A      | 1.287 | 1.215 | 1.847  | 0.928 | 0.876 | 0.888  | 0.293 | 0.333 | 0.187  |

Note: 1A= Batu Mundom Village; 1B= Batang Toru near of mouth of river; 1C= Muara Opu swamp; 2A= Batang Toru River in Bandar Tarutung Village; 2B= Mabang Pasir; 2C= Siais Lake; 3A= Batang Toru near Trikora Bridge; 3B= Pasaliran River; 3C= Batang Toru River near mouth of river Pasaliran; 4A= Sitandiang River; 4B= Sitandiang mouth of river; 4C= Batang Payah River; 4D= Malakut River; 4E= Malakut Mouth of river; 4F= Aik Sikkut; 4G= Aik Toras; 4H= Sigumuruh River; 5A= Batang Toru River in Hutaimbaru

In the observation conducted in July 2019, the diversity index value ($H'$) varied from 0.377 to 1.215 which indicates that all observation times were in the low-medium diversity category. A small diversity index value was found at Station 4A, while a fairly large diversity index value was found at Station 5A. The zooplankton evenness index (E) in these observations varied between 0.544-0.981 which belonged to the medium-high evenness category for the entire observation time. A fairly small evenness index was found at Station 4A, and a fairly large uniformity index was found at Station 4C. Based on the results of observations for that month, the dominance index (D) varied between 0.278-0.781 which means low-high. A small index was found at Station 3A, while a fairly large index of dominance is found at Station 4A.
that in general the zooplankton conditions in the Batang Toru River area and its surroundings have low-medium diversity values, medium-high uniformity and low-high dominance.

In the observation of October 2019, the diversity index value ($H'$) varied from 0.349 to 1.847, which indicates that all observation times were in the low-medium diversity category. A small diversity index value was found at Station 4G, while a fairly large diversity index value was found at Station 5A. The zooplankton evenness index ($E$) in these observations varied between 0.503-0.985 which belonged to the medium-high evenness category for the entire observation time. A fairly small uniformity index is found at 4G Station, and a fairly large evenness index was found at Station 2C. The dominance index ($D$) varied between 0.24-0.802 which means high, a small index was found at Stations 3B and 4E, while a sizable index of dominance was found at 4G stations. Based on observations in October, it was known that in general the zooplankton conditions in the Batang Toru River area and its surroundings have low-medium diversity values, medium-high evenness and low-high dominance. Based on the overall observation, the diversity, uniformity and dominance indices ranged from 0.349 to 1.847, 0.503-0.994 and 0.240-0.802, respectively. Such conditions indicated that the Batang Toru River ecosystem has small-medium diversity, medium-high uniformity and low-high dominance.

3.2. Discussion

Zooplankton (in total) found in the waters of the Batang Toru River and its surroundings consist of 6 groups based on Phylum, namely Ciliophora, Amoebozoa, Coccozoa, Rotifera, Arthropoda, and Annelida. Based on the number of genera, zooplankton consists of 16 genera (depending on the time of capture). In April 2019 observations, 6 genera were obtained, July observations obtained 14 genera, and October 2019 observations obtained 10 genera. Amoebozoa, Coccozoa, Rotifera phylum were found in greater numbers than another phylum. Based on the generation, the most common zooplankton species are Arcella sp, followed by Diffugia sp and Euglypha sp. The type and abundance of zooplankton in the waters always fluctuates. A similar condition in research zooplankton in Kucukcekmece Lake (Turkey) [13].

When compared with the zooplankton observations in other rivers, the zooplankton condition in the waters of the Batang Toru River and its surroundings is different (although in terms of the number of genera is similar). Observations of zooplankton in the Je'neberang Sungguminasa River (Kec. Somba Opu Kab. Gowa, South Sulawesi) found 9-17 genera belonging to the phylum Arthropoda, Cnidaria, Annelida, and Echinodermata. The dominant zooplankton in the river is Lucifer [3]. This result is also different from the zooplankton in the Pepe River (Tenga Java) which found 12 genera from 5 main divisions namely Ciliophora (2 genus), Rotifera (5 genus), Arthropoda (1 genus), Protozoa (3 genus) and Platyhelminthes (1 genus) [14].

Based on the identification of zooplankton in the Majakerta River (West Java), it is known that the composition of the zooplankton species found in the river consists of groups of Protozoa (10 genera), Crustacea (4 genera), and Rotifera (4 genera). The composition of the zooplankton species found varied, both based on time and location of observation. The composition of organisms in the river is dominated by the Protozoa group [5]. Different conditions are also known from the results of the analysis of zooplankton samples in the Rungan River (Palangkaaya), which consists of 2 groups of zooplankton namely Rotifera and Capepoda, with each genera being Polyartha sp, Trichocerca sp, Testudinella sp, Mytilina sp, and Lecane sp (Phylum Rotifera) and Megacyclops sp (Phylum Capepoda) [6]. Different conditions were also found in the zooplankton in the Mempawah River Estuary. The river is found quite a lot (55 genera) which are divided into five phyla. Most genera were found in the phylum Arthropoda (29 genera) and the lowest was Annelida (1 genus) [10]. From the comparisons of several rivers, it is known that the types of zooplankton found vary, although there are several types (genera) that are the same, but the number and composition of the species are different. This situation shows that the zooplankton in an ecosystem is very dynamic and shows both type and quantity.

Based on its abundance, the zooplankton found in the waters of the Batang Toru River and its surroundings range from 1103-10521 ind./m$^2$ (from 16 genera). Different results observing the zooplankton genus with a total abundance of 9600 ind./L [7]. The greatest abundance of zooplankton
was found in the Diifflugia genus of 2400 ind. Tintinnidium (with the same abundance as 800 ind./L) [7]. Also stated a different matter. From the results of research on the Je'neberang Sungguminasa River (Somba Opu District, Gowa Regency), 26 species of zooplankton were found including Phylum Arthropoda, Annelida, Asteroidae and Cnidaria [3]. The composition of the zooplankton species at all observation stations is dominated by Crustacean Class, with an abundance of zooplankton ranging from 54 ind/m³ - 702 ind/m³ [3].

The abundance of zooplankton in the waters of the Batang Toru River, at each observation station, ranges from 1103-10 521 cells/l. This abundance value is higher than the zooplankton research results in Jepara waters. This situation is thought to also occur due to the availability of sufficient food (phytoplankton) for zooplankton growth, this can be seen from the high abundance of phytoplankton [5]. Zooplankton (especially the Protozoa, Crustacea and Rotifera groups), apart from eating phytoplankton, can also eat organic or suspended matter [14].

The Batang Toru River area and its surroundings are inhabited by various types of fish. One of the natural foods of fish is zooplankton. Various types of zooplankton are found as food for various types of fish that live in river areas. The high abundance of zooplacontes in these waters can be an indication that fisheries potential is also quite high. Research in related lakes, stated that there is a relationship between zooplankton and environmental conditions [15]. A similar condition is also relationship between zooplankton (especially Dinoflagellates) and nitrates, nitrites, ammonia, phosphates and salinity [16]. In addition, the movement of the zooplankton zooplankton community structure will have implications for the food web process in a waters (estuary) [17]. By conducting this research, the potential of the Batang Toru River waters as a habitat for various organisms, especially plankton, can be developed. Based on this description, the zooplankton community structure in the waters of the mouth of the Batang Toru River can be the information needed for the management of fisheries resources to be sustainable and sustainable.

Biological indices that were observed were diversity index (H'), uniformity index (E), and dominance index (D). These indices show the diversity of species in a community as well as the balance of the number of individuals of each species. The results of calculations at each station and time of observation show that the zooplankton diversity index value in April, July, and October is included in the low to moderate category as the criteria that the value of $H' \leq 1$ includes low diversity and a value of $1 \leq H' \leq 3,000$ is medium diversity and moderate community stability [18], the zooplankton diversity index values obtained ranged from 0.349 to 1.847 (table 3).

If the damage to the Batang Toru River is seen based on the diversity index value, it can be explained that the Batang Toru River is included in the category of moderate damage. Zooplankton uniformity index values ranged from 0.503 to 0.994 (table 3). In general, between each station and the time of observation, there were more uniformity index values that had a value greater than 0.5 than those with a value less than 0.5. The uniformity index value higher than 0.5 indicates that the distribution of individuals for each species is relatively uneven, while the low uniformity index value (less than 0.5) indicates that the distribution of individuals for each species in the community is relatively even. Dominance index describes the presence or absence of species that dominate other species. The results of the calculation show that there are more values that are close to 0 (zero) than those that are close to 1 (one), thus it can be explained that in general the Batang Toru River does not occur during the research zooplankton dominance, dominance only occurs at location and time. certain. The range of dominance index values was 0.240-0.802 (table 3).

4. Conclusions
The composition of zooplankton species in the Batang Toru River during the study was dominated by *Arcella* sp. Phytoplankton biological indices such as diversity index (H') are included in the low to moderate category, the uniformity index (E) is small to moderate, and the dominance index value can be explained that there are species that dominate other species.
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