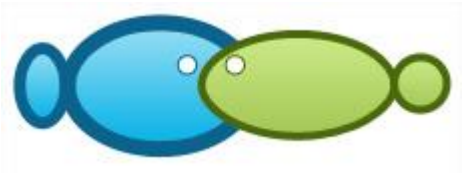

Plankton diversity and dominance in Bilah River, Labuhanbatu Regency, North Sumatra, Indonesia

[1]Ika R. Purba, [2]Arman Harahap, [3]Erlina P. Mahadewi, [4]Chairul I. Ilham, [1]Ade P. Nasution, [1]Masrizal, [5]Oda K. Banurea

[1] Department of Biology Education, Faculty of Teacher Training and Education, Simalungun University, Pematangsiantar, Indonesia; [2] Labuhanbatu University, Labuhanbatu, North Sumatra, Indonesia; [3] Esa Unggul University Jakarta, Indonesia; [4] Inland Water and Ferries Transport Polytechnic of Palembang, Palembang, Indonesia; [5] STIT Al-Ittihadayah Labuhan Batu Utara, Nort Sumatra, Indonesia. Corresponding author: I. R. Purba, ikarosenta318@gmail.com

Abstract. The Bilah River, a vital watercourse in Northern Sumatra, particularly traversing densely populated urban areas like Rantauprapat, has experienced significant pollution from industrial, agricultural, and commercial activities, impacting its habitat. The aim of this study was to assess the plankton diversity index in the Labuhanbatu Bilah River. The research utilized the purposive random sampling method across three observation stations: station 1, characterized by various community activities such as domestic waste, sand mining, and agriculture; station 2, featuring domestic waste, cage fish farming, and agriculture; and station 3, marked by community activities like bathing, domestic waste, and agriculture. The plankton composition analysis in the Bilah Labuhanbatu River revealed three classes of phytoplankton (Bacillariophyceae, Chlorophyceae, and Cyanophyceae) and four classes of zooplankton (Mastigophora, Monogononta, Crustacea, and Ciliophora). The highest diversity index of phytoplankton was recorded at station 1, in the sand mining area, with a value of 1.76, indicating a medium level of diversity. In zooplankton, the highest diversity index was observed at station 3 with a value of 0.42, indicating a low level of diversity. Meanwhile, the highest dominance index for phytoplankton was found at station 3, in a densely populated area, with a value of 0.51, while for zooplankton, it was identified at station 1, in a sand mining area, with a value of 0.00487. Both values suggested that no plankton genus dominated the respective areas. The highest zooplankton diversity index was identified at station 3, with a value of 0.42, indicating a low level of diversity.
Key Words: phytoplankton, pollution level, Shannon-Wiener, zooplankton.

Introduction. The Bilah River, a major watercourse in Northern Sumatra, particularly traversing densely populated urban areas, like Rantauprapat in Labuhanbatu Regency, is of vital significance. The river basin, which encompasses a considerable expanse, has undergone considerable transformation due to industrial and commercial activities, including agriculture, fishing, sand mining, and transportation, leading to apparent signs of habitat pollution (Harahap et al 2018; Harahap et al 2021). The survey outcomes, coupled with insights from the local community, reveal extensive utilization of Bilah River water by the residents of Serdang Menang Village for various activities, ranging from household needs to fishing, sand mining, and agriculture. This multifaceted interaction with the river significantly alters the aquatic environment. Aquatic environment is a dynamic interplay of biotic and abiotic components, orchestrated through energy flows and nutrient cycles (Ray et al 2021). Any changes in this ecosystem invariably impact the planktonic organisms. Plankton, consisting of small organisms adrift in water currents, serves as a vital indicator of water conditions (Maulud et al 2021). Recognizing the potential implications of these human activities on the aquatic ecosystem, it becomes imperative to scrutinize the diversity of plankton in the Labuhanbatu Bilah River (Harahap et al 2020a). Several studies have reported on plankton diversity assessments and ecological characteristics in Sumatra, including those conducted in the Belawan River (Yeanny et al 2018,2023), Burai River (Fatiqin 2019), and Ogan River (Marson & Harmilia

2021). Such an investigation is crucial, not only for understanding the intricate dynamics of this ecosystem but also for generating foundational data that can contribute to assessments pertaining to the water quality of the Bilah River. The findings of this study are intended to provide a valuable baseline for gauging the ecological health of the river and, subsequently, to inform strategies for sustainable water resource management in the region.

Material and Method

Sampling procedure. This research was conducted from January to March 2023 in the Bilah River, Labuhanbatu Regency, Rantauprapat District, North Sumatra Province, Indonesia. The tools utilized included cover glass, film bottles, paper labels, microscopes, plankton nets, plastic buckets, secchi disks, thermometers, dissolved oxygen (DO) meters, pH meters, cameras, pipettes, stationery, and measuring cups. Water samples were collected from the Labuhanbatu Bilah River for analysis. The study adopted a descriptive method to investigate the diversity of plankton in the Labuhanbatu Bilah River. Plankton sampling was carried out using the purposive random sampling method at three designated points along the river. The sampling procedure involved preparing a plankton net and collecting water samples using a 5 L bucket. The collected water samples were then passed through the plankton net, a process repeated ten times until the total water sample volume reached 50 L. Subsequently, the water collected at the end of the plankton net was transferred to a 200 mL sample bottle. To facilitate the identification and analysis, 2 mL of the sample was mixed with Lugol's solution. The sample bottle was then shaken until the mixture achieved homogeneity, resulting in a brownish appearance. The sample bottle was tightly sealed, labeled with information on the station, time, and place, and transported to the Labuhanbatu University Biology Laboratory for further analysis and identification of plankton species. This meticulous methodology ensures a comprehensive understanding of the plankton diversity in the Labuhanbatu Bilah River and provides valuable data for ecological assessments and water quality evaluations.

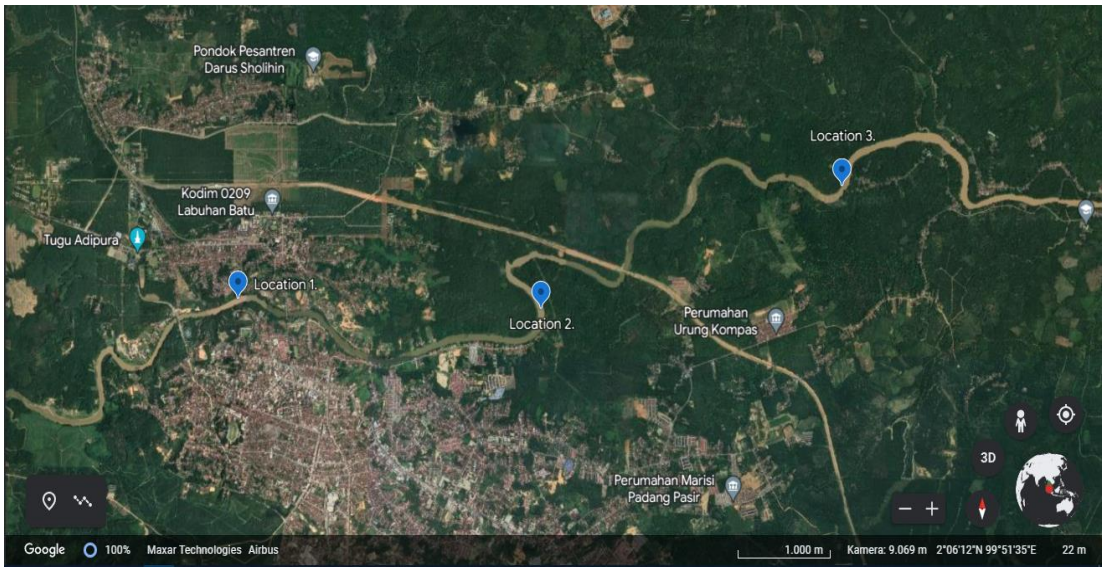

Figure 1. Study site and adjacent stream in the Bilah River.

Data analyis. Diversity index analysis is used to determine the diversity of species of aquatic organisms. The equation used to calculate this index refers to the Shannon-Wiener equation (Shannon & Weaver 1963), as follows:

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Where:
H' - diversity index;
S - total number of species;
Pi - ni/N;
ni - total number of individuals of the species i;
N - total number of individuals in the sample.

The diversity index criteria are divided into 3 categories, namely:
H' < 1 = low diversity
1 < H' < 3 = moderate diversity
H’ > 3 = high diversity

The dominance index is used to determine the relative abundance of certain species in waters using the Simpson's formula equation (Simpson 1949), as follows:

$$D = 1 - \sum_{i=1}^{N}(p_i)^2$$

Where:
D - dominance index;
ni – total number of individuals of the species i (ind);
N - total amount of plankton per sample (ind);
Pi - ni/N.

Results and Discussion. The results of plankton identification in the Bilah Labuhanbatu River revealed a diverse composition of plankton genera across different classes. In the phytoplankton category, the Bacillariophyceae class encompassed 11 genera, including *Coscinodiscus, Cymbella, Diatoma, Epithemia, Fragilaria, Melosira, Navicula, Nitszthia, Pinularia, Surirella*, and *Synendra*. Within the Chlorophyceae class, there were 12 genera, namely *Ankistrodesmus, Closterium, Cosmarium, Cyclotella, Gleocystis, Gonatozygon, Mougeotia, Oedogonium, Pediastrum, Pleurotaenium, Scenedesmus, Staurastrum, and Stigeoclonium farctum*. The Cyanophyceae class exhibited 6 genera: *Gomphospaheria, Hydrodiction, Merismopedia, Oscilllatoria, Phormidium, and Stigeonema*. Concerning zooplankton, it included 3 classes. The Mastigophora class featured 4 genera: *Difflugia, Euglena, Phacus,* and *Trachelomonas*. The Monogononta class comprised 6 genera: *Asplanchna, Keratella, Lecane, Monostyla, Notholca*, and *Trichocerca*. The Crustacean class contained 1 genus, *Nauplius*, and the Ciliophora class had 1 genus, *Stentor*. The presence of various phytoplankton and zooplankton genera signifies a complex and interconnected food web, contributing to the overall health and balance of the river ecosystem. These findings contribute to our understanding of the intricate relationships within aquatic environments and can serve as a foundational dataset for further ecological studies and water quality assessments in the Bilah River (Harahap et al 2022). From the data presented in Table 1, the highest average diversity index of phytoplankton was observed at station 1, located in the sand mining area, with a value of 1.36, followed by station 2, in the floating net cage fish farming area, with a value of 1.26.

According to the Shannon-Wienner index, these values suggest that the phytoplankton diversity at both stations falls within the moderate category. A diversity index value between 1 and 3 indicates moderate diversity, moderate distribution, sufficient productivity, a fairly balanced ecosystem, and moderate ecological pressure. The moderate diversity values at stations 1 and 2 imply favorable conditions for phytoplankton growth (Striebel et al 2012). Conversely, at station 3, situated in a densely populated area, the average diversity index was 0.98, indicating low phytoplankton diversity. According to the Shannon-Wienner index, a value below 1 reflects low diversity, an unstable and poor ecosystem, with very low productivity and increased ecological pressure. The low phytoplankton diversity at station 3 might be attributed to inadequate adaptation caused by high population activity in the densely populated residential area. The addition of organic and inorganic waste materials in

water, as reported Luthfia (2013), not only alters the chemical composition but also affects the biological properties of water, potentially decreasing the species diversity.

Table 1

Average index of plankton diversity (H') in Bilah River

Station	*Phytoplankton diversity (H')*	*Zooplankton diversity (H')*
Station-1 (Sand mining area)		
Point 1	1.60	0.29
Point 2	1.50	0.17
Point 3	1.04	0.07
Average	1.36 (Moderate)	0.19 (Low)
Station-2 (Floating net cage)		
Point 1	1.13	0.27
Point 2	1.17	0.25
Point 3	1.65	0.06
Average	1.26 (Moderate)	0.15 (Low)
Station-3 (Urban area)		
Point 1	1.48	0.21
Point 2	0.72	0.52
Point 3	0.70	0.21
Average	0.96 (Low)	0.30 (Low)

The zooplankton diversity index values at each sampling station were as follows: station 1 (sand mining area) showed an average value of 0.17, station 2 (floating net cage aquaculture area) had an average value of 0.16, and station 3 (densely populated area) displayed an average value of 0.31. These values, according to the Shannon-Wiener diversity index, suggest that zooplankton diversity falls into the low category. The low zooplankton diversity may be attributed to difficulties in adapting to environmental conditions, limited availability of phytolactone as a food source, and potential cannibalism among zooplankton due to insufficient food (Wahlstrom et al 2000). The observed patterns highlight the intricate interplay between anthropogenic activities, environmental conditions, and plankton diversity in Bilah River. The obtained plankton dominance index values are presented in Table 2.

Table 2

Average index of plankton dominance (D) in Bilah River

Station	*Phytoplankton dominance (D)*	*Zooplankton dominance (D)*
Station-1 (Sand mining area)		
Point 1	0.16	0.15
Point 2	0.27	0.0003
Point 3	0.57	0.0004
Average	0.33	0.0048
Station-2 (Floating net cage)		
Point 1	0.37	0.0
Point 2	0.39	0.0
Point 3	0.23	2.0
Average	0.33	0.0002
Station-3 (Urban area)		
Point 1	0.24	0.002
Point 2	0.43	0.000
Point 3	0.60	0.002
Average	0.42	0.0012

Data indicate that the highest dominance index of phytoplankton is observed at station 3, situated in a densely populated area, with an average dominance index value of 0.43. Conversely, the lowest average dominance index values are recorded at stations 1 and 2, corresponding to the floating sand mining area, with a value of 0.33. For the zooplankton dominance index, the highest value is documented at station 1, in the sand mining area, reaching 0.00563, while the lowest values are noted at stations 2 (floating net cage fish farming) and 3 (densely populated area), registering 0.0013 and 0.0010, respectively. These values suggest an absence of a dominant genus at the three stations. This findings aligned with previous theories, emphasizing the absence of a dominant genus in the sampled areas, with species occupying the majority of niche (Baquero et al 2021; Harahap et al 2020b). The loss of a dominant species can trigger significant alterations not only in the biotic community but also in the physical environment (Hillebrand et al 2008). The dominance of a particular plankton type may serve as an indicator of water pollution or suboptimal conditions, where only certain species can thrive and adapt to the prevailing environmental parameters (Zhang et al 2021).

Conclusions. In conclusion, the planktonic community in the Bilah Labuhanbatu River exhibits a diverse composition, encompassing three classes of phytoplankton - Bacillariophyceae, Chlorophyceae, and Cyanophyceae - and three classes of zooplankton - Monogononta, Crustacea, and Ciliophora. The diversity indices serve as crucial indicators of the ecosystem health and environmental conditions in this river. The highest phytoplankton diversity index, indicating a moderate level of diversity, was recorded at station 1 in the sand mining area, with a value of 1.36. This observation suggests that the phytoplankton community in this region is thriving and exhibits a balanced ecosystem condition. On the other hand, zooplankton diversity reached its peak at station 3, with a diversity index of 0.42, categorizing it in the low diversity range. This lower diversity level may be attributed to factors such as environmental stressors or limited adaptation capabilities of the zooplankton to the prevailing conditions. Furthermore, dominance indices provide insights into the prevalence of specific plankton types in different areas. The highest dominance index for phytoplankton occurred at station 3, situated in a densely populated area, with a value of 0.50. This suggests potential environmental stress and altered ecosystem conditions in this region. In contrast, the highest dominance index for zooplankton was identified at station 1 in the sand mining area, recording a value of 0.00486. This low dominance implies a more balanced distribution of the zooplankton genera, contributing to a healthier aquatic ecosystem. These findings emphasize the need for ongoing monitoring and assessments to understand and manage the factors influencing the ecological balance of this vital waterway.

Conflict of interest. The authors declare no conflict of interest.

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Received: 09 October 2023. Accepted: 12 January 2024. Published online: 31 January 2024.
Authors:
Ika Rosenta Purba, Simalungun University, Faculty of Teacher Training and Education, Department of Biology Education, Pematangsiantar, 21151, Indonesia, e-mail: ikarosenta318@gmail.com
Arman Harahap, Universitas Labuhanbatu, Labuhanbatu, North Sumatra, 21461, Indonesia, e-mail: armanhrahap82@gmail.com
Erlina Puspitaloka Mahadewi, Universitas Esa Unggul Jakarta, 11470, Indonesia, e-mail: erlina.puspitaloka@esaunggul.ac.id
Chairul Insani Ilham, Inland Water and Ferries Transport Polytechnic of Palembang, Palembang, 30962 Indonesia, e-mail: chairul@poltektranssdp-palembang.ac.id
Ade Parlaungan Nasution, Universitas Labuhanbatu, Labuhanbatu, North Sumatra, 21461, Indonesia, e-mail: adenasution@gmail.com
Masrizal, Universitas Labuhanbatu, Labuhanbatu, North Sumatra, 21461, Indonesia, e-mail: masrizal20405@gmail.com
Oda Kinata Banurea, STIT Al-Ittihadayah Labuhan Batu Utara, Nort Sumatra, Indonesia, e-mail: odakinata5@gmail.com

How to cite this article:
Purba I. R., Harahap A., Mahadewi E. P., Ilham C. I., Nasution A. P., Masrizal, Banurea O. K., 2024 Plankton diversity and dominance in Bilah River, Labuhanbatu Regency, North Sumatra, Indonesia. AACL Bioflux 17(1):142-147.