Correlation Of Macrozoobenthos Diversity Index With Physico-Chemical Factors In Lake Toba, Toba Samosir Regency

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Abstract.

This study aims to determine the macrozoobenthos in Lake Toba, Toba Samosir Regency. This research was conducted from May to July 2018. Determination of research stations based on environmental baseline consisted of 4 stations, namely station 1 in Lumban Binanga Laguboti village, station 2 in Lumban Bul-bul Balige, station 3 in Lumban Binanga Sigumpar, and station 4 in Hutagaol Sigumpar. Samples were taken using Eckman Grab at 3 times at each station. The macrozoobenthos found consisted of two classes, three orders, eight families, 15 species with a total of 565 individuals. The species found were Brotia subgloriosa, Brotia peninsularis, Brotia castulata, Pomacea diffusa, Pomacea paludosa, Filopaludina polygramma, Filopaludina sp., Melanoides tuberculata, Lymnaea sp., Emilia sp., Corbicula sumatrana, Corbicula fluminea, Corbicula japonica, Pilsbryoconcha exilis, and Anodonta sp.. The macrozoobenthic species with the highest number of individuals was Corbicula sumatrana with 141 individuals and the least was Lymnea sp. by 1 individual. The macrozoobenthos ecological analysis included the average density of 2260, the average diversity index of 1.282, the average uniformity index of 0.633, and the average dominance of 0.390. Then correlated with physico-chemical factors using Pearson correlation (r). Correlation of diversity index with physico-chemical factors from the strongest to the weakest starting from depth and phosphate, turbidity, temperature, pH, BOD, and DO.

Keywords: *Environmental baseline, station, species and Pearson's correlation.*

I. INTRODUCTION

Lake Toba includes fresh waters inhabited by various aquatic organisms. Macrozoobenthos are animals that live on the bottom of the water and have limited movement. Macrozoobenthos are animals that live at the bottom of the waters and act as biological indicators that react to changes in water quality (Noviyanti *et al*. 2019).The movement of macrozoobenthos is very low so that it can be used as a bioindicator of water quality, changes in water quality will have a significant impact on macrozoobenthos (Bayan *et al*. 2016; Susetya *et al*. 2018 & A. Harahap, P. Hrp, 2020). Macrozoobenthos is an indicator of waters because it has a permanent habitat, thus changes in the quality of its water habitat will affect its abundance and composition (Asra, 2013 & Harahap, A, et, all, 2022.). The research results on the Cikidang River have obtained 14 species, including 12 genera, 9 families, 3 classes, and 2 phyla (Hidayat *et al*, 2023). Macrozobenthos can be used as an indicator in a waters because of its limited movement so that it is easily exposed to foreign materials that enter the waters. There are more and more community activities in Lake Toba which may affect the presence of macrozobenthos in Lake Toba. Macrozoobenthos obtained only in Toba Samosir Regency. The macrozoobenthic data that will be known includes the density, diversity, uniformity, and dominance of macrozoobenthos, as well as data on aquatic physicochemical parameters as supporting data for analyzing macrozoobenthic communities in the aquatic environment of Lake Toba, Toba Samosir Regency, North Sumatra.

II. METHODS

This research was conducted from May to July 2018 on Lake Toba, Toba Samosir district. The research stations were determined based on the environmental baseline, so four stations were chosen, namely: station 1 in Lumban Binanga Laguboti village, station 2 in Lumban Bul-bul Balige, station 3 in

Lumban Binanga Sigumpar, and station 4 in Hutagaol Sigumpar. Sampling with the Eckman grab, the data is already available so it only exposes macrozoobenthos data found in Lake Toba, Toba Samosir district. Then analyzed density, diversity index, uniformity index, and dominance. Then look for the Pearson (r) correlation between the diversity index and the physico-chemical factors of Lake Toba water in Toba Samosir district. According to Rijaluddin, 2017, the abiotic factors are physical-chemical quality of water, including temperature, current, dissolved oxygen (DO), biological oxygen demand (BOD), as well as nitrogen (N) content, water depth, and substrate.

III. RESEARCH RESULT

Macrozoobenthos found in Lake Toba, Toba Samosir Regency The macrozoobenthos found in Lake Toba, Toba Samosir Regency, North Sumatra consist of 2 classes, namely Gastropods and Pelecypoda. Gastropods obtained consisted of six families, namely: three species of Pachychilidae family, two species of Ampullariidae family, two species of Viviparidae family, one species of Thiaridae family, one species of Lymnaeidae family and one species of Pleuroceridae family. The macrozoobenthos of the Pelecypoda class obtained consisted of two families, namely: the Cyrenidae family of three species and the Unionidae family of two species. Macrozoobenthos species found in the Lake Toba area, Toba Samosir Regency, North Sumatra are presented in table 1:

Table 1. Macrozoobenthos species found in Lake Toba, Toba Samosir Regency and their classification

Class	Order	Family	**Species**
Gastropoda	Mesogastropoda	Pachychilidae	*Brotia subgloriosa*
			Brotia peninsularis
			Brotia castulata
		Ampullariidae	*Pomacea diffusa*
			Pomacea paludosa
		Viviparidae	*Filopaludina polygramma*
			Filopaludina sp.
		Thiaridae	*Melanoides tuberculata*
		Lymnaeidae	*Lymnaea sp.*
		Pleuroceridae	*Emilia sp.*
Pelecypoda	Veneroida	Cyrenidae	*Corbicula sumatrana*
			Corbicula fluminea
			Corbicula japonica
	Unionoida	Unionidae	*Pilsbryoconcha exilis*
			Anodonta sp.

The macrozoobenthos found consisted of two classes, three orders, eight families, 15 species with a total of 565 individuals. Each species found was 6 individuals of *Brotia subgloriosa*, 6 individuals of *Brotia peninsularis*, 75 individuals of *Brotia castulata*, 3 individuals of *Pomacea diffusa*, 9 individuals of *Pomacea paludosa*, 8 individuals of *Filopaludina polygramma*, *Filopaludina sp*. 72 individuals, *Melanoides tuberculata* 73 individuals, *Lymnaea sp*. 1 individual, *Emilia sp*. 21 individuals, *Corbicula sumatrana* 141 individuals, *Corbicula fluminea* 125 individuals, *Corbicula japonica* 11 individuals, *Pilsbryoconcha exilis* 12 individuals, and *Anodonta sp.* 2 individuals. The macrozoobenthic species with the highest number of individuals was *Corbicula sumatrana* with 141 individuals and the least was *Lymnea sp.* by 1 individual. The macrozoobenthos found were not of the same species at each research station. Species found at each station and their frequency of presence are presented in table 2.

Table 2. Frequency of Macrozoobenthos During Research

Species	Station 1 (ind)	Station 2 (ind)	Stasiun 3 (ind)	Stati0n 4 (ind)	Presence Frequency (%)
Brotia subgloriosa	3	1	2		75
Brotia peninsularis		1	4	1	75
Brotia castulata	47		24	4	75
Pomacea diffusa	3				25
Pomacea paludosa	4	2		3	75
Filopaludina polygramma	8				25

Filopaludina sp.	1			71	50
Melanoides tuberculata		67		6	50
Lymnaea sp.		1			25
Emilia sp.		9	2		50
Corbicula sumatrana	65	15	55	6	100
Corbicula fluminea		6	102	17	75
Corbicula japonica	11				25
Pilsbryoconcha exilis	12				25
Anodonta sp.		2			25
Amount	154	104	199	108	

The percentage of each type of macrozoobenthos found in Toba Lake Samosir district can be seen in Figure 1.

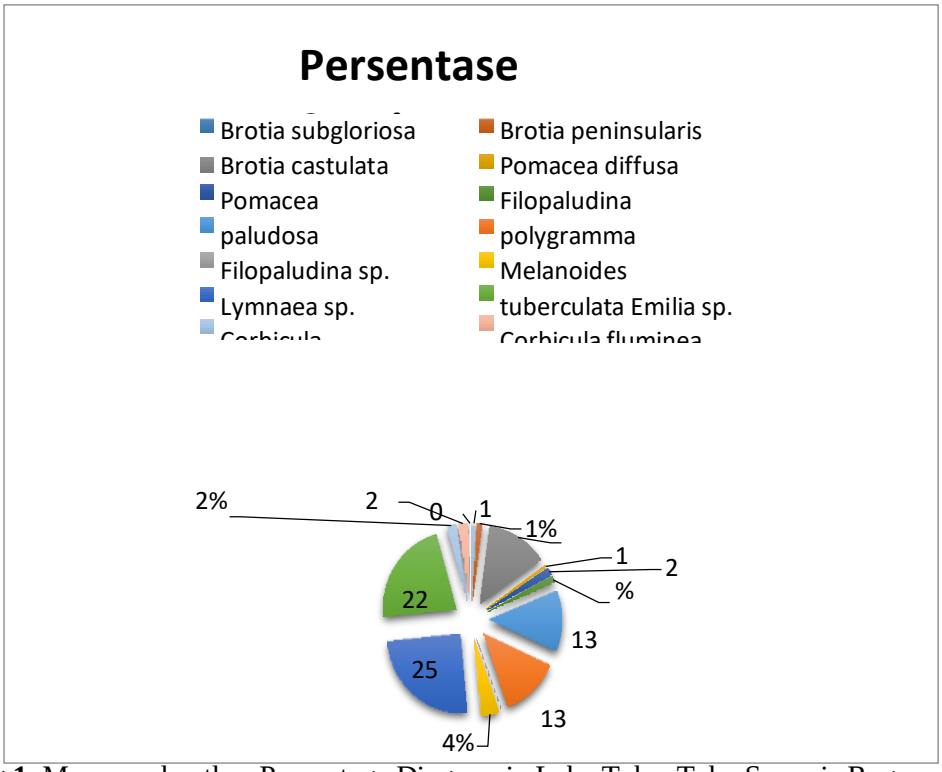

Fig 1. Macrozoobenthos Percentage Diagram in Lake Toba, Toba Samosir Regency

Based on the results of the percentage diagram of Macrozoobenthos in the Lake Region Toba, Toba Samosir Regency, North Sumatra, from the 15 species obtained, it was found that the dominant macrozoobenthic species was *Corbicula sumatrana* (25%), and the least was *Lymnaea sp.* only 0.002% and Adononta sp is 0.004%, because the numbers are given without commas, both are written zero percent (0%). Ecology of macrozoobenthos in Lake Toba, Toba Samosir district

Table 3. Density Value, Diversity Index (H'), Uniformity Index (E), Dominance (D).

Factor (Indeks)	**Station**				
	1	2	3	4	Rataan
Density Value	2464	1664	3184	1728	2260
Diversity Index (H')	1,548	1,181	1,247	1,153	1,282
Uniformity Index (E)	0,705	0,537	0,696	0,592	0,633
Dominance (D)	0,287	0,448	0,358	0,465	0,390

Based on table 2, station 3 has the highest density of 3184 ind/m2, followed by station 1 of 2464 ind/m2. The high density of macrozoobenthos at station 3 is thought to be due to the high organic content of the substrate as a food ingredient, which strongly supports the growth of macrozoobenthos. Substrates that are rich in organic matter are usually supported by an abundance of deposit feeder fauna such as snails or gastropods (Odum, 1993). The abundance value of macrozoobenthos is between 481.5 – 278 Ind/m2. The diversity index value is at a value of 1.15 – 1.45. The uniformity index value is at a value of 0.45 – 0.59 (Arini *et al*, 2023). The macrozoobenthos diversity index at the four stations ranged from 1.153 to 1.548 with

an average of 1.282. The highest diversity index is at station 1, which is 1.548 in the moderate category, the lowest diversity index is at station 4, which is 1.153, also in the medium category. According to Odum (1993), species diversity is influenced by many things, including habitat types, environmental stability, productivity, competition, and food buffers. According to the grouping of degrees of water pollution based on the Shannon Wiener Diversity Index (H') according to Sastrawijaya (2000), Lake Toba, Toba Samosir Regency, is included in the moderately polluted waters group.

The macrozoobenthos uniformity index obtained at each station ranged from 0.537 to 0.705 with an average of 0.632. The highest uniformity index value is 0.705 at station 1, the lowest uniformity index is at station 2 of 0.537. At station 1 the number of each species did not dominate, while at station 2 there were species that dominated, namely *Melanoides tuberculata*. The uniformity index in the waters of Toba Lake Toba Samosir Regency at the four stations as a whole shows a value that is close to 1, in other words the distribution of the macrozoobenthos population is quite good, this can be demonstrated by the presence of macrozoobenthos species found at the four stations, namely Corbicula Sumatrana, although at the station certain types of domination occur, namely at stations 2 and 4, this can be influenced by the type of substrate and water conditions.The highest dominance index is at station 4, which is 0.465 with the medium dominance category, and the lowest is at station 1 of 0.287 with the low category. The dominance index obtained at the four stations showed nothing close to 1, but the Dominance Index value at station I was almost close to 0 which indicated that there was a dominating species, namely Corbicula sumatrana with a total of 65 individuals or around 42% of the total individuals found at that station. According to Dimas *et al.* 2020, the diversity index is 1.53 - 1.79. The uniformity index is 0.45 - 0.53. There is a difference in species deficit in each.

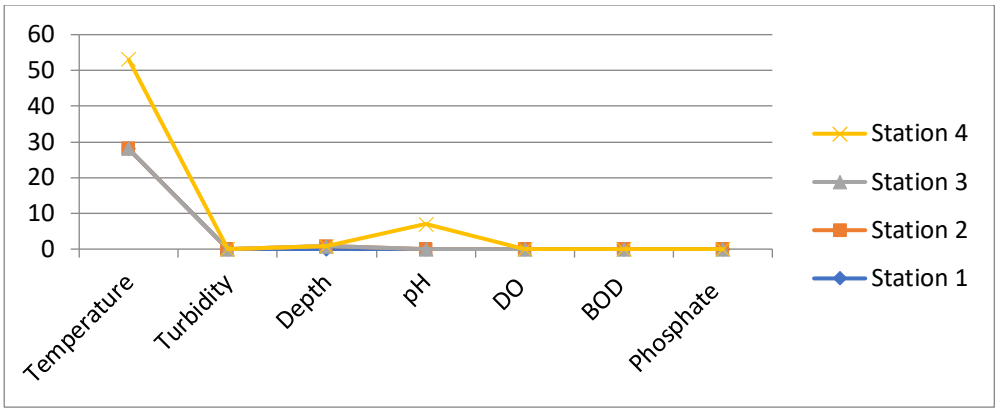

Fig 2. Graph of Physico-Chemical Factors

a. Temperature The water temperature at the four stations ranged from 26.33-27.33oC. The temperature at station I is 28oC, the highest temperature of the four stations, sampling during the day and quite a lot of community activities in the presence of residential areas. The temperature at station 2 is in second place, namely 27.33 there are water tourism activities around the station. The temperature at station 3 is 26.33oC, including moderate temperature, sampling is around 10 am, and there are quite a lot of water hyacinth and other aquatic plants. The lowest temperature is at station 4, which is 25oC, sampling is done in the afternoon and there is little activity in these waters.

b. Turbidity Turbidity can limit the entry of sunlight into the water, thereby affecting the levels of dissolved oxygen (DO) in the water. Turbidity can occur due to high sedimentation, also related to depth, currents, temperature and type of substrate. The highest turbidity was found at station 1, which was 8.36 with a muddy sand substrate, while the lowest turbidity value was at station 3.

c. Depth The depth at station 1 is 1.13 m, there is activity of taking sand from the waters by the surrounding community, the lowest depth value is obtained at station 2, which is 0.81 m, this is very suitable for the use of the waters as a place of recreation water. According to Simatupang *et al*, 2017, the depth of the waters will affect the distribution pattern or distribution of the macrozoobenthos in the waters.

d. pH The pH values at all research stations ranged from 6.66 to 7.66. The high pH at stations 1 and 2 can be caused by detergent, soap or shampoo entering the waters because the waters of station 1 are residential

areas, while station 2 is a tourist spot. According to Santoso (2017), the presence of detergent, shampoo in water will increase the pH value of the water so that it disrupts the life of microorganisms. Water conditions that are very acidic or very alkaline will endanger the survival of organisms because it will interfere with metabolism and respiration. The degree of acidity (pH) of these waters is still suitable for class I and II water (pH: 6-9).

e. Dissolved Oxygen (DO) The DO or dissolved oxygen values obtained at the four stations ranged from 8.07-8.5 mg/l, the highest value was found at station 2. According to Barus (2004), the dissolved oxygen value in the waters should be between 6-8 mg/l , the lower the DO value, the higher the level of pollution. The DO level at all observation stations is greater than the DO level according to the Water Quality Standard, so the waters of Lake Toba, Toba Samosir Regency, are suitable for use as class I and II water. The high solubility of oxygen at station 2 was 8.11 and station 3 was 8.5 due to the temperature factor. According to Barus (2004) one of the factors that greatly affects the solubility of oxygen in water is water temperature, if the temperature increases, the solubility of oxygen will decrease and vice versa. Dissolved Oxygen (DO) in waters affects the number and types of macrozoobenthos (Nurfajrin & Rosada 2018).

f. Biological Oxygen Demand (BOD) According to Sinambela (2015), BOD is a description of the need for oxygen by aerobic microorganisms to carry out the metabolism of organic matter in water so that it indirectly indicates the presence of organic matter in water, the higher the BOD value, indicates that the water contains a lot of organic matter in it. Observations at the four stations obtained BOD values ranging from 2.00-2.94 mg/l, with the highest levels at station 3 of 2.94 mg/l and the lowest at station 2 of 2.00 mg/l. The high BOD at station 3 is probably due to pollution due to waste or organic discharge into the waters. According to the Class I and Class II Water Quality Standards (< 2 mg/l), the waters at all stations are still suitable for use as class II water.

g. Phosphate Phosphate values obtained at the four research stations ranged from 0.09-0.39 mg/l. The highest phosphate content was found in station 1, which was 0.39 mg/l and had exceeded the water quality standards of class 1 and 2 (0.2 mg/l), while the lowest value was found at station 4 which was 0.09. The high value of phosphate at station 1 occurs due to the entry of waste into the waters thereby increasing the value of phosphate in the waters.

h. Substrate type

Table 4. Substrate Types Station Fraction (%)

Station	Fraction (%)			Type
	Sand	Mud	Clay	
Station I	65 %	30%	5%	Sandy Loam
Station II	85%	10%	5%	Sand
Station III	55%	35%	10%	Clai Clay
Station IV	10%	75%	15%	Clay Dusty

Based on table 4. it can be known the type of substrate at stations 1, 2, 3, and 4. Pearson Correlation Analysis (r) Between Physical-Chemical Conditions and Diversity Index (H') of Macrozoobenthos Based on measurements of the physico-chemical factors of the waters that have been carried out at each research station, and correlated with the Diversity Index (H'), the Correlation Index values are obtained as in table 5:

Table 5. Value of Pearson Correlation Analysis (r) Between Diversity and Physical-Chemical Factors in Lake Toba Waters

H'	Temperature	Turbidity	Depth	pH	DO	BOD	Phosphate
R	0,718	0,806	0,971	0,658	-0,366	0,030	0,971

Based on table 5 it can be seen the results of the Pearson correlation analysis test between several physical and chemical factors of waters. Correlation of diversity index with physico-chemical factors from the strongest to the weakest starting from depth and phosphate each was 0.971, turbidity was 0.806, temperature was 0.971, pH was 0.658, BOD was 0.030, and DO was -0.366. Correlation index values between depth, phosphate, turbidity, temperature, and pH with diversity of macrozoobenthos have a strong degree of relationship. This shows that the physico-chemical factors mentioned above have a positive effect on the macrozoobenthic diversity index, with conditions in direct proportion.

IV. DISCUSSION

Based on the results of the study, the macrozoobenthos found in Lake Toba, Toba Samosir Regency, North Sumatra, consist entirely of 2 classes, namely the Gastropods and Pelecypoda classes. Of the 15 macrozoobenthos species obtained, the Gastropod class had the highest species, namely 10 species. This could be due to the sandy bottom substrate of Lake Toba waters in Toba Samosir district, making it very suitable for the habitat of the Gastropod class. According to Nur et al, 2023, 4 macrozoobenthos classes were found at the study site, namely the Gastropod Class (4 species), the Crustacean Class, the Ophiuroidea Class, and the Oligochaeta Class, each with 1 species. The Gastropods group can be found at every station starting from stations with good environmental conditions to stations with declining water quality conditions indicating that this species has a wide life span. Macrozoobenthos generally prefer to live on muddy substrates rather than sandy substrates (Saputra et al. 2017). The type of macrozoobenthos with the highest number and found at the four stations was *Corbicula sumatrana* from the Cyrenidae family, Pelecypoda class, namely 141 individuals, with the highest number at station 1 as many as 65 individuals and the least at station 4 as many as 6 individuals, this can be influenced by aquatic substrates at stations 1, 2 and 3 which have a high sand fraction.

Plays an important role in determining the presence and morphological size of *Corbicula sumatrana*. At the four stations there is a species of *Corbicula sumatrana*. The population of this species at a location where the substrate was muddy sand was higher than the muddy substrate, as at station 4, only 6 species were found. At station 2, several species were found that did not exist at other stations, namely Anodonta sp. and *Lymnaea sp.*, *Anodonta sp*. This animal is classified as a filter feeder, namely a type of animal that gets food by filtering the water that enters its body. This species can regulate the level of oxygen metabolism well so that it can still live in conditions where oxygen levels in the water are very low. Station 3 has the highest number of macrozoobenthos but the least composition of macrozoobenthos. The most species at station 3 are from the Cyreniade family of the genus Corbicula which are benthic animals that inhabit muddy and sandy bottoms and harder substrates, usually living sessilely on the substrate, many of these species are found at station 3 because the water substrate is clay. clay and sand. Macrozoobenthos at station 4 consists of 5 families, namely the families Ampullaridae, Pachychilidae, Viviparidae, Thiaridae and Cyrenidae, the most abundant species is Filopalaudina polygramma from the family viviparidae.

This species generally lives in calm or slow waters, is usually active at night, and rests at night. during the day, immerse yourself in sand or mud or stick to other rough substrates, this is according to the type of substrate at station 4 which is muddy and not much activity around the waters. Based on the index value of macrozoobenthic diversity, the waters of Lake Toba, Toba Samosir district has moderate macrozoobenthic community stability, the Uniformity Index value in Lake Toba waters does not show any uniformity value that is close to the maximum value, in other words the population distribution of macrozoobenthos in Toba Lake Toba Samosir Regency is still dominated by certain species. The dominance index obtained at all stations showed nothing close to 1, but the Dominance Index value at station I was almost close to 0 which indicated that there was a dominating species. In general, water quality parameters in the Lake Toba area, Toba Samosir Regency, still support the presence of macrozoobenthos, which is indicated by the presence of macrozoobenthos at each station. If the uniformity value is close to 0, it means that the uniformity is stable because there are species that dominate, and if the uniformity value is close to 1, the uniformity is stable, which shows that no species dominates (Alwi *et al*, 2020).

V. CONCLUSION

The macrozoobenthos found consisted of two classes, three orders, eight families, 15 species with a total of 565 individuals. The species found were *Brotia subgloriosa*, *Brotia peninsularis*, *Brotia castulata*, *Pomacea diffusa*, *Pomacea paludosa*, *Filopaludina polygramma*, *Filopaludina sp.*, *Melanoides tuberculata*, *Lymnaea sp.*, *Emilia sp.*, *Corbicula sumatrana*, *Corbicula fluminea*, *Corbicula japonica*, *Pilsbryoconcha exilis*, and *Anodonta sp.*. Macrozoobenthic ecological analysis included the average density of 2260, the average diversity index of 1.282, the average uniformity index of 0.633, and the average dominance of 0.390. Correlation of diversity index with physico-chemical factors from the strongest to the weakest starting

from depth and phosphate each was 0.971, turbidity was 0.806, temperature was 0.971, pH was 0.658, BOD was 0.030, and DO was -0.366. The bottom substrate at station 1 is sandy loam, at station 2 is sandy, at station 3 is sandy loam, and at station 4 is dusty loam. Correlation index values between depth, phosphate, turbidity, temperature, and pH with diversity of macrozoobenthos have a strong relationship and are directly proportional.

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