Community Structure of Macrozoobenthos in Lake Limboto

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Abstract

This study aims to determine the structure of the macrozoobenthic community in Limboto Lake, Gorontalo Province. Sampling was carried out at 5 stations and 3 repetitions using the Ekman Grab tool and prepared with a filter with a net size of 100 µm. Collecting data using purposive random sampling method and the influence of the macrozoobenthic community structure with physical and chemical parameters was analyzed using the CANOCO 4.5 application. The results showed that the macrozoobenthic community structure in Limboto Lake varied, with the diversity index at Station 1 and Station 2 being in the medium category, Station 3, Station 4 and Station 5 being classified as low, the uniformity index at Station 1 and Station 2 was evenly distributed, Station 3, Station 4 and Station 5 are uneven. The dominance index at Station 3, Station 4 and Station 5 shows that there are species that dominate. The highest total macrozoobenthic abundance was at Station 3, namely 427,643 individuals / m3 and the lowest was at Station 2, namely 2,038 individuals / m3. The results of the analysis showed that the substrate had the greatest influence on the macrozoobenthic community structure and was followed by other physical-chemical parameters.

Keywords: Macrozoobenthos; Lake Limboto; community structure.

I. Introduction

Lake Limboto is experiencing changes with the occurrence of fast-moving silting due to eutrophication caused by the growth of biomass such as water hyacinth and other aquatic plants which account for about 70% of the lake area. If these plants dry out, they will sink to the bottom of the lake and cause sedimentation. In addition, one of the contributing factors to the increasingly loss of the lake area is fishing activities with floating nets that use bamboo as a support for the net, and every time the bamboo sinks, it is not removed and ends up as garbage on the bottom of the waters which results in changes to the substrate which affects the diversity and abundance of biota in Limboto Lake (Suryono., et al., 2010).

Changing the quality and quantity of waters greatly affects both the composition and diversity of aquatic biota, given the strategic role of Lake Limboto, its preservation needs to be considered so that it can be utilized for a longer period of time, at least being able to extend its life. To achieve a maximum management, it is important to understand the response of organisms to the changes that will occur (Sahami, 2006).

Organisms that are commonly used as bio-indicators are macrozoobenthos, because they are sensitive to pollutants and have a long survival. Therefore, the role of macrozoobenthos in the balance of an aquatic ecosystem can be an indicator of current ecological conditions in certain areas (Purnami, et al., 2010).

Changes in water quality and the living substrate of macrozoobenthos greatly affect their abundance and diversity. Macrozoobenthos are classified as animals that can be seen visually and pass a filter measuring less than 500 µm (Untung et al., 1996 in Kadim, 2017).

Because the changes in the depths of Lake Limboto are getting shallower from year to year and there is still little information about the macrozoobenthic community structure, it is necessary to conduct studies on macrozoobenthos and water physics-chemical parameters (temperature, dissolved oxygen, degree of acidity (pH), depth and brightness, and type of substrate) as a supporting factor for macrozoobenthic life in Lake Limboto. Therefore, the authors are interested in conducting research with the title Community Structure of Macrozoobenthos in Lake Limboto, Gorontalo Province.

II. Research Methods

Macroozobenthos samples were sorted and identified at the Laboratory of Hydrobiotechnology and Biometrics, Universitas Negeri Gorontalo. The research location and sampling station points can be seen in Figure 2.

The tools used in sampling are Ekman grabs, plastic bags, label paper, buckets, cameras and ATMs as well as tools for measuring water quality including DO meters, pH meters, Secchi disks, and meters.

Determination of station points based on cardinal directions, water in and out, and locations that have characteristics in Limboto Lake. Station locations include, Station 1 is in Biyonga which is the inlet area of Lake Limboto, Station 2 is in Bulota which is a rice field area, Station 3 is in Iluta which is an area with floating fish cages (KJA), Station 4 is in Dembe which is an area with a dam , and Station 5 is in Tilango which is the outlet area of Lake Limboto.

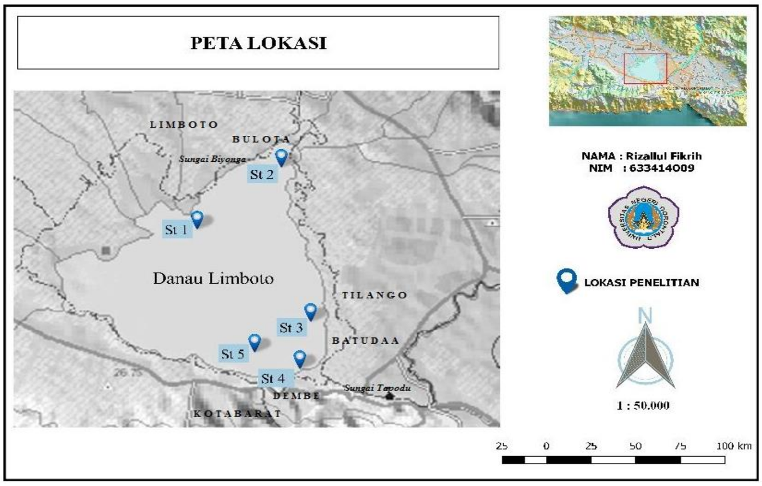

Figure 1. Map of the research stations

The macrozoobenthic sampling procedure refers to the APHA (1989), and uses a purposive random sampling method. The parameters observed in this study were macrozoobenthic and water quality. Data collection includes primary and secondary data. Primary data is macrozoobenthic sampling and water quality measurement, while secondary data is literature studies, such as journals, theses, books, e-books, as supporting data. The stages of the research procedure were first to measure the quality of water. Sampling of macro-zoobenthos was carried out at 5 stations with 3 repetitions, then preparation to clean the macrozoobenthic sample, sorting and identification. Data analysis to determine the macrozoobenthic community structure in Lake Limboto, including abundance, diversity index of Shannon Wiener, uniformity index, dominance index of Simpson and the effect of chemical physics parameters on macrozoobenthic community structure in Lake Limboto using CANOCO 4.5.

III. Results and Discussion

3.1 Macrozoobenthos composition

There were found 19 macrozoobenthos genera belonging to the Gastropod, Bivalvian, Crustacean, Insecta and Oligochaeta classes.

Macrozoobenthos found in the first sampling consisted of 15 genera from 5 classes (Gastropoda, Bivalvia, Crustacea, Insecta and Oligochaeta). In the second sampling, Macrozoobenthos consisted of 16 genera from 4 classes (Gastropoda, Bivalvia, Insecta and Oligochaeta). The distribution of each type of macrozoobenthic organism at each observation station can be seen in Table 1.

Table 1 Genus and distribution of Macrozoobenthos at stations

No	Organisms	Sampling 1 (26/04/2018)					Sampling 2 (03/05/2018)				
		St. 1	St. 2	St. 3	St. 4	St. 5	St. 1	St. 2	St. 3	St. 4	St. 5
	Gastropoda										
1	*Melanoides sp.*	√	√	√	√	√	√	√	√	√	√
2	*Thiara sp.*	√	√	√	√	√	√	√	√	√	√
3	*Tarebia sp.*	—	—	—	—	—	—	—	—	√	—
4	*Bellamya sp.*	√	—	—	—	—	√	√	√	—	√
5	*Wattebledia sp.*	√	√	—	√	√	—	—	—	—	—
6	*Bythinia sp.*	—	—	—	—	—	—	—	√	—	—
7	*Anentome sp.*	√	—	—	—	—	—	—	—	—	—
8	*Gyraulus sp*	√	—	—	—	—	√	√	—	—	—
9	*Lymnea sp.*	√	√	—	—	—	√	—	—	—	—
10	*Physastra sp.*	—	—	—	—	—	√	—	—	—	—
11	*Pomacea sp.*	√	—	—	√	—	—	—	√	√	√
12	*Pila sp.*	—	—	√	√	—	—	—	√	√	—
	Bivalvia										
13	*Anodonta sp.*	—	—	—	√	—	—	—	√	—	—
14	*Limnoperna sp.*	—	—	—	—	—	—	—	√	—	—
15	*Acroloxus sp.*	—	—	—	√	—	—	—	—	√	—
16	*Polypyilis sp.*	—	—	—	—	—	—	√	√	—	—
	Crustacea										
17	*Parathelpusa sp.*	—	—	—	—	√	—	—	—	—	—
	Insecta										
18	*Chironomus sp.*	√	—	—	—	—	√	—	—	—	—
	Oligochaeta										
19	*Limnodrilus sp.*	√	√	—	√	√	√	√	—	√	—

Station 1 in the first sampling consisted of 65 individuals from 3 classes (Gastropods, Insects and Oligochaeta) and in the second sampling there were 31 individuals, with the composition of macrozoobenthos found including: 62 gastropods, namely Melanoides sp. totaling 30 individuals, Thiara sp. totaling 35 individuals, Bellamya sp. total 2 individuals, Wattebledia sp. amounting to 1 individual, Anentome sp. totaled 2 individuals, Pomacea sp. amounted to 1 individual and each individual was only found in the first sampling, Gyraulus sp. and Pomacea sp. each of 2 individuals, Lymnea sp. totaled 4 individuals, Physastra sp. amounted to 1 individual and only found in the second sampling. Class Insect from the genus Chironomus sp. a total of 15 individuals, 13 individuals in the first sampling and 2 individuals in the second sampling. Oligochaeta class of the genus Limnodrilus sp. amounting to 1 individual both in the first sampling and the second sampling.

The number of Macrozoobenthos found at Station 2 in the first and second sampling were 16 individuals from 2 classes in the first sampling (Gastropods and Oligochaeta) and 3 classes in the second sampling (Gastropoda, Bivalvia and Oligochaeta). The compositions of macrozoobenthos found at Station 2 include: Melanoides sp. a total of 5 individuals, Thiara sp. total of 7 individuals, Bellamya sp. totaled 2 individuals, Lymnea sp. amounted to 1 individual and Gyraulus sp. amounting to 1 individual of each type was only found in the second sampling, Wattebledia sp. amounting to 1 individual was only found in the first sampling. Bivalvian class of the genus Polypyilis sp. which was only found in the second sampling amounted to 1 individual. Limnodrilus sp. from the Oligochaeta class a total of 14 individuals, 10 individuals in the first sampling and 4 individuals in the second sampling.

Station 3 becomes the station with the highest number of individual macrozoobenthos compared to other stations. The number of macrozoobenthos found at Station 3 was 5.128 individuals in the first sampling from the Gastropod class and 1.586 individuals in the second sampling from the Gastropod and Bivalvian class. Gastropod classes found include: Melanoides sp. amounting to 2.303 in the first sampling and 626 in the second sampling, Thiara sp. totaled 2.822 individuals in the first sampling and 936 in the second sampling, Bellamya sp. amounting to 1 individual, Bythinia sp. totaled 14 individuals, Pomacea sp. amounting to 2 individuals, each type was only found in the second sampling. Pila sp. amounted to 3 individuals in the first sampling and 2 individuals in the second sampling. Bivalvia class from the genus Anodonta sp., Limnoperna sp., and Polypyilis sp. each of 1 and 2 and 2 individuals were only found in the second sampling.

The number of macrozoobenthos found at Station 4 was 1.737 individuals in the first sampling and 1.332 individuals in the second sampling. Macrozoobenthos found belong to the class Gastropods, Bivalves, and Oligochaeta in both the first and second sampling. Gastropod class found include the genus Melanoides sp. amounted to 846 individuals in the first sampling and 653 individuals in the second sampling. Thiara sp. amounted to 863 individuals in the first sampling and 655 individuals in the second sampling. Tarebia sp. and Pomacea sp. 4 and 2 individuals respectively were found only in the second sampling. Pila sp. amounted to 3 individuals in the first sampling and 2 individuals in the second sampling. The bivalves found, among others, are from the genus Anodonta sp. amounted to 1 individual and only found in the first sampling, Acroloxus sp. amounted to 3 individuals in the first sampling and 1 individual in the second sampling. Oligochaeta class of the genus Limnodrilus sp. amounted to 3 individuals in the first sampling and 8 individuals in the second sampling.

The number of macrozoobenthos found at Station 5 was 431 individuals in the first sampling and 510 individuals in the second sampling. Macrozoobenthos found were from the Gastropoda, Bivalvian, and Oligochaeta classes in the first sampling and only from the Gastropod class in the second sampling. Gastropod class found, among others, from the genus Melanoides sp. with a total of 191 individuals in the first sampling and 242 individuals in the second sampling. Thiara sp. with 233 individuals in the first sampling and 266 individuals in the second sampling. Bellamya sp. and Pomacea sp. each of 1 individual was found only in the second sampling. Wattebledia sp. amounted to 1 individual and was only found in the first sampling of Genus Parathelpusa sp. of the Crustacean class is the only type of macrozoobenthos which was only found at Station 5 in the first sampling with a total of 3 individuals. Limnodrilus sp. of the Oligochaeta class amounted to 3 individuals and were only found in the first sampling.

Based on the identification results, many organisms from the Gastropod class and from the Genus Melanoides sp. and Thiara sp.. According to Tanjung (1995) gastropods have a higher adaptability than other benthic animals.

This is supported by the body structure, a cone-shaped shell which can minimize the impacting power of the waves and can relatively move and stick to the substrate where they live. In addition, the spread of the genus Melanoides sp. found at each research station indicate that the genus has a high degree of tolerance to environmental changes. In addition, the genus Melanoides sp. generally found in shallow waters with sandy or muddy substrate types (Suartini, 2005).

3.2 Abundance of Macrozoobenthos

The abundance of macrozoobenthos in Limboto Lake can be seen in Figure 2.

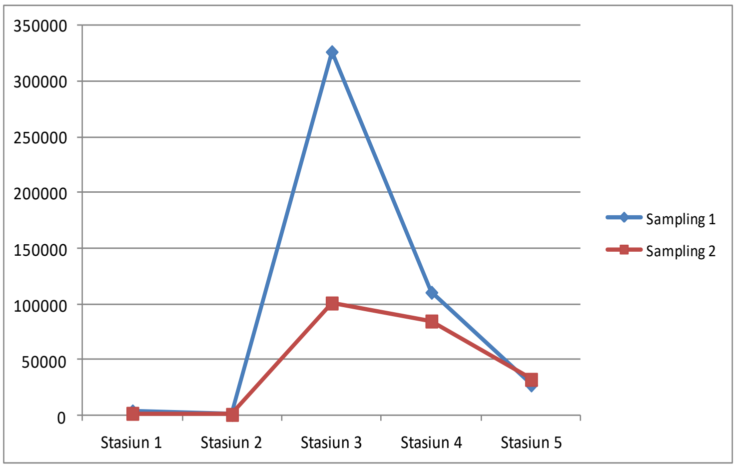

Figure 2 Abundance of Macrozoobenthos in Lake Limboto

Figure 2 shows that the total abundance of macrozoobenthos found was 6.115 individuals / m3 at Station 1. At Station 2, the total abundance was 2.038 individuals / m3. At Station 3 the total abundance is 427.643 individuals / m3. At Station 4, the total abundance is 195.478 individuals / m3, and at Station 5 the total abundance is 59.936 individuals / m3. Figure 4 also shows that the highest abundance of macro-zoobenthos is at Station 3 and the lowest is at Station 2. The high value of abundance at Station presumably because it is an area of floating net cages, where tilapia is cultivated, where food waste and feces become organic material. In addition, the growth of water hyacinth weeds further adds to the content of organic matter. The high level of organic matter at Station 3 is a source of nutrients for the surrounding biota. According to Nurracmi and Marwan (2012), macrozoobenthos is closely related to the availability of organic material contained in the substrate, because organic matter is a source of nutrients for biota found in the base substrate.

The lowest total macrozoobenthos abundance is found at Station 2. The low abundance of macrozoobenthos at Station 2 is suspected because it is a place surrounded by rice fields, where rice fields usually use pesticides in agricultural activities and if used excessively it can cause pollution waters and mortality in biota.

According to Sha (2010) in Kadim (2012) that pesticide contamination can occur when pesticides are used excessively. The soil around the plants will be polluted and kill small creatures in the soil, including bacteria, fungi, protozoa, worms, and insects. Water pollution by pesticides occurs through the flow of water from human activities that use pesticides in order to increase agricultural production. High levels of pesticides in water can kill aquatic organisms. Even low levels of pesticides in water can poison small organisms.

3.3 Diversity, uniformity, and dominance Indexes

The diversity index, uniformity index, and dominance index at each station are presented in Table 2.

Table 2. Diversity, uniformity, and dominance indexes of macrozoobenthos

Indexes	Stations				
	1	2	3	4	5
Diversity (H')	1,7	1,6	0,7	0,8	0,8
Uniformity (E)	0,7	0,8	0,3	0,4	0,4
Dominance (D)	0,3	0,3	0,5	0,5	0,5

The diversity index values of the five stations ranged from 0.7 to 1.7. Station 1 and 2 have a diversity index value <3, this indicates that the diversity at Station 1 and 2 is in the medium category. The medium level of diversity shows that the distribution of individuals for each species is uneven. This is due to the smaller number of species and there are several more individuals, resulting in ecosystem instability (Prasetia, 2017). Stations 3, 4 and 5 have low diversity index values. The low diversity index value obtained shows that, the distribution of the number of individuals for each genera / species is low, the stability of the community is low and the condition of the waters is starting to be polluted (Odum, 1993 in Tenribali, 2015).

The highest diversity index value was at Station 1, namely 1.7, based on the results of water quality measurements at Station 1 in the second sampling, the measured oxygen content was the second highest, which was 6.5. This concurs with Darojah (2005). The higher the O2 level, the higher the diversity of macrozoobenthos.

The lowest diversity index value is at Station 3, Station 4 and Station 5, when viewed from the distribution of individual macrozoobenthos at Station 3 and Station 5, only a few types of macrozoobenthos are obtained. Station 3 only has 3 species (Melanoides sp., Thiara sp., and Pomacea sp.) In the first sampling, while at Station 5 there are only 4 types (Melanoides sp., Thiara sp. Bellamya sp., and Pomacea sp.) on the second sampling. Diversity includes two important things, namely the number of types in a community and the abundance of each type, so that the smaller the number of species and the variation in the number of individuals of each type has an uneven distribution, the diversity will decrease (Odum, 1998 in Yasir, 2017).

The measured water quality data is that the temperature at Station 4 is the highest, the temperature value is inversely proportional to the value of dissolved oxygen, the higher the temperature, the lower the dissolved oxygen value and vice versa.

The uniformity index value at Station 1 and Station 2 is close to 1, which means that the individual distribution of each species at Station 1 and Station 2 is evenly distributed and no species dominates, while at Station 3, Station 4 and Station 5 it is close to 0, meaning that the individual distribution of each species at Station 3 , Station 4 and Station 5 are uneven and there is a dominant biota, namely from the genus Melanoides sp. and Thiara sp., supported by the type of substrate from Station 3, Station 4 and Station 5, namely muddy substrate, makes the abundance of these organisms. This agrees with Suartini (2005) that the number of genus Melanoides sp. because the genus likes to live in mud and sand substrates. According to Prasetia (2017) the uniformity value is almost close to the maximum value, in other words the spread of the macrozoobenthic population is quite good, indicated by the many types of macrozoobenthos found at each station even though certain stations dominate certain types. This may be related to the condition of the waters or the type of substrate that may not support the population.

The domination index value at Station 1 and Station 2 is close to 0, and at Station 3, Station 4 and Station 5 it is close to 1.The domination index value is between 0 - 1, where the smaller the dominance index value, it shows that no species dominates, on the contrary the more large value of the dominance index, it shows that there is dominance of certain species (Odum, 1993).

3.4 Physical and chemical parameters of the waters

Water quality parameters measured during the study included dissolved oxygen, temperature, pH, brightness, and depth. The physical and chemical conditions of Lake Limboto waters during the observation are presented in Table 3.

Table 3. Physical and chemical properties of the waters

No	Parameters	Sampling I*					Sampling II*				
		1	2	3	4	5	1	2	3	4	5
1	Temp. (°C)	33,6	30,4	31,2	28,9	31,1	32	28,2	30,6	35,7	31
2	DO (mg/l)	4,4	5,6	5,9	6,7	5,5	6,5	4,9	4,9	6,2	5,6
3	pH	6,5	5,1	5,6	6,3	6	6,9	6,8	6,5	7,5	7
4	Bright. (cm)	37,5	32	48	54	60	13,5	21,5	31	91	40
5	Depth (cm)	100	124	400	291	250	50	150	400	300	150
6	Substrate	2	2	1	1	1	2	1	1	1	1

Based on measurements, the temperature in the Limboto Lake waters ranges from 28.9 - 35.7ºC. The highest temperature measured at Station 4 in the second sampling is 35.7ºC and the lowest temperature at Station 4 in the first sampling is 28.9 ºC. Generally, the temperature at each station is relatively similar and in accordance with the temperature range required for the macrozoobenthos. According to the results of research by Zahidin (2008) in Izzah and Roziaty (2016) the optimal water temperature for the growth of macrozoobenthic animals ranges from 25–35°C.

Dissolved oxygen (DO) ranges from 4.4 to 6.7 mg / L. The highest dissolved oxygen is found at Station 4, the first sampling, seen from the temperature value at the first sampling Station 4, seen from the temperature value is one of the lowest, this agrees with Sastrawijaya (2000), temperature has a big influence on the solubility of oxygen in water, when the water temperature increases, the solubility of oxygen in the water decreases. Along with increasing temperature will also result in an increase in aquatic metabolic activity. Increased activity of aquatic metabolism causes respiration which requires a lot of dissolved oxygen, so that dissolved oxygen levels in the waters decrease and vice versa, carbon dioxide levels increase. The lowest dissolved oxygen value was found at Station 1 at the first sampling, at the time of sampling at Station 1, the weather was scorching hot which caused the temperature to be high, this affected the DO value.

DO values in Limboto Lake are still in normal conditions to support macrozoobenthic life. According to Saparinto (2007), the DO levels that are needed by macrozoobenthos range from 4.00–6.00 mg / l and based on the results of Marpaung's (2013) research, the DO range in waters that support the macrozoobenthos sample community ranges from 4-6 mg / l.

The degree of acidity (pH) measured during the study ranged from 5.1-7.5. The highest pH value measured at Station 4 in the second sampling was 7.5 because seen from the temperature measurement at Station 4 in sampling 1 it was the highest temperature value, while the lowest pH was at Station 2 in the first sampling which was 5.1, because when taking water samples at water surface, the weather around the station location is raining, so that the pH of the surface water which tends to be acidic is influenced by the current weather factor. The pH range in Lake Limboto is still suitable for macrozoobenthic life. This agrees with Effendi (2003) in Lubis, et al (2013) that the appropriate pH value for macrozoobenthic life is 7-8.5 and is not suitable for pH <5 and> 9.

The brightness level at Limboto Lake ranges from 13.5-90 cm. The brightness in Limboto Lake looks cloudy due to the growth of weeds that almost fill the surface of Lake Limboto. According to Zahidin (2008), the brightness of the waters is much influenced by the fine materials floating in the waters, both in the form of organic matter (plankton, microorganisms, and detritus) and inorganic (mud and sand particles).

The depth at each station ranges from 50-400 cm. The deepest sampling location is Station 3 which is 400 cm, in the floating net cage area of the Iluta wharf, and the lowest is at Station 1, the second sampling is 50 cm. The depth of a water is related to the abundance of macrozoobenthos, where the increase in water depth is followed by a decrease in the abundance of macrozoobenthos, on the other hand the abundance of benthic macrozoos is higher in shallow waters (Sulistiyarto, 2008).

The types of substrates at the five stations are not much different, namely substrates belonging to a diameter of 0.006 - 2 mm and 0.004 - 0.06 mm, with a score of 1 and 2. According to Odum (1994) in Ummami (2012), the basic substrate or soil texture is a very important component for the life of organisms. The substrate at the bottom of the waters will determine the abundance and species composition of the macrozoobenthos.

3.5 Effect of physical – chemical properties on Macrozoobenthos community structure

Physical - chemical parameters such as temperature, depth, brightness, DO, pH and substrate can affect the abundance of macrozoobenthos. The effect of physico-chemical parameters in this study is presented in Figure 3.

The CCA triplot ordination graph shows the effect of physico-chemical parameters on each type of macrozoobenthos in this study. Based on the results of CCA analysis, it was found that the abundance of markrozoobenthos such as Anentome sp., Physastra sp., Chironomus sp., Lymnea sp., Gyraulus sp., Bellamya sp., Melanoides sp., Thiara sp., Polypylis sp., Anodonta sp., Melanoides sp., Thiara sp., Polypylis sp., Anodonta sp. , Bythinia sp., And Limnoperna sp. influenced by the substrate and based on linear RDA analysis, it has a length of gradient value of 0.461. The abundance of Thiara sp. because the substrate in Limboto Lake is mud and sandy mud.

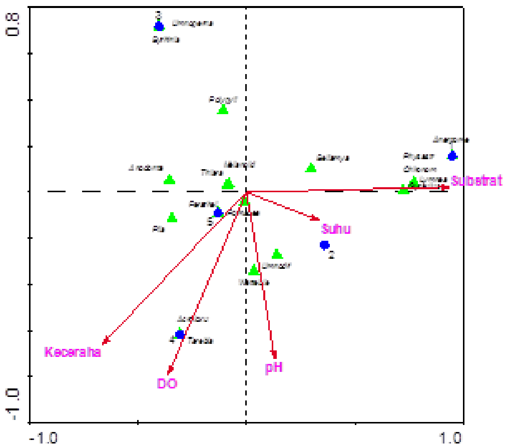

Figure 3. Graph of triplot ordination relationship between macrozoobenthic species and physico-chemical parameters of water

According to Simamora (2012), Thiara sp. is also one of the macrozoobenthic genus that likes sandy mud bottom habitats. Abundance Chironomus sp. also influenced by the substrate. According to Sinaga (2009), Chironomus sp. is one of the macrozoobenthos of the Insecta Class which can be found in polluted, muddy waters and water bodies covered by vegetation.

Abundance of Parathelpusa sp. and Pila sp. located at Station 5 is influenced by Brightness and based on linear RDA analysis, it has a length of gradient value of 0.112. Judging from the value of water quality at Station 5, it has a high brightness value in the first sampling, which is 60 cm. The ability to penetrate light to a certain depth will also affect the distribution and way of macrobenthos in foraging for food (Barus, 2004).

An abundance of Macrozoobenthos species Acroloxus sp., Tarebia sp., And Pomacea sp. located at Station 4 is influenced by DO (Dissolved Oxygen) and based on linear RDA analysis, it has a length of gradient value of 0.019. Judging from the DO value found at Station 4 is the highest at Station 4, namely 6.7 in the first sampling.

Based on the results of linear RDA analysis, temperature also affects the abundance of Pomacea sp. with a length of gradient value of 0.003. Macrozoobenthos from the genus Limnodrilus sp. and Wattebledia sp. pH, based on linear RDA analysis, has a length of gradient value of 0.019. Judging from the water quality value, the pH at Station 2 is the lowest (tends to be acidic). According to Gufran and Andi (2009), at low pH (high acidity) the dissolved oxygen content will decrease, causing the organism's respiration activity to increase. The opposite happens in an alkaline water atmosphere.

Based on the results of the CCA triplot ordination (Figure 3) it shows that, almost half of the macrozoobenthic species found, their abundance is influenced by the length of gradient value of the substrate, namely 0.461. This means that the substrate is the limiting factor that most influences the community structure of the macrozoobenthos. Changes in water quality and substrate greatly affect the abundance and diversity of macrozoobenthos.

IV. Conclusion

The macrozoobenthic community structure in Lake Limboto varies, with the composition of the macrozoobenthos found consisting of 19 genera from 5 classes (Gastropoda, Bivalvia, Crustacea, Insecta, and Oligochaeta). Diversity index ranges from 0.7 to 1.7 and belongs to the low-medium category. The uniformity index at Station 1 and 2, namely 0.7 and 0.8 indicates an even distribution, Stations 3, 4 and 5 have a uniformity index value of 0.3-0.4 indicating an uneven distribution, the dominance index value at Station 3, 4 and 5, namely 0.3-0.5, indicating that the dominant species of the genus Melanoides sp. and Thiara sp.. The total abundance of macrozoobenthos in Lake Limboto ranged from 2.038-427.643 individuals / m3 with the highest abundance of macrozoobenthos at Station 3 and the lowest at Station 2.

Based on the analysis results from Canonical Correspondence Analysis (CCA), it shows that the substrate is the physico-chemical parameter that has the most influence on the macrozoobenthic community structure, followed by other physico-chemical parameters such as brightness, DO, pH and temperature.

References

APHA American Public Health Association. 1989. Standard Methods for The Examination of Water and Waste Water. Ed ke-17. Washington D.C : APHA.

Barus, T. A. 2004. Pengantar Limnologi Studi Tentang Ekosistem Air Daratan. Medan: USU Press.

Darojah, Y. 2005. Keanekaragaman Jenis Makrozoobentos di Ekosistem Perairan Rawapening, Kabupaten Semarang . Skripsi. Semarang : UNNES

Effendi, H. 2003. Telaah Kualitas Air Bagi Pengelolaan Sumberdaya dan Lingkungan Perairan. Kanisius. Yogyakarta.

Izzah N. A, Roziaty, E. 2016. Keanekaragaman Makrozoobentos Di Pesisir Pantai Desa Panggung Kecamatan Kedung Kabupaten Jepara. Bioeksperimen Volume 2 No.2, (September 2016) ISSN 2460-1365. Surakarta

Kadim, Miftahul Khair. 2012. Ekologi Komunitas Makrozoobentos Sungai Umbulrejo Di Kecamatan Dampit Kabupaten Malang. Tesis. Program Magister Fakultas Perikanan Dan Ilmu Kelautan Universitas Brawijaya Malang

_______. 2017. Komunitas Makrozoobentos. Yogyakarta : Zahir Publishing.

Lubis, S.M. Basyuni, M. Suryanti, A. 2013. *Keanekaragaman dan Kelimpahan Makrozoobentos di Sungai Naborsahan Kabupaten Toba Samosir Sumatera Utara.* Program Studi Manajemen Sumberdaya Perairan, Fakultas Pertanian, Universitas Sumatera Utara : Medan

Marpaung, A. A. (2013). *Keanekaragaman Makrozoobenthos Di Ekosistem Mangrove Silvofishery Dan Mangrove Alami Kawasan Ekowisata Pantai* Boe Kecamatan Galesong Kabupaten Takalar. Makasar: Universitas Hasanuddin Makasar.

Odum EP. 1971. *Fundamental of Ecology*. Ed ke-3. Philadelphia: W.B Saunders Co

_______. 1993. Dasar-Dasar Ekologi. Edisi ketiga.Terjemahan : Samingan, T.,Srigandono. Fundamentals Of Ecology. Third Edition. Gadjah Mada University Press.

Prasetia, R. 2017. Keanekaragaman Makrozoobentos Sebagai Indikator Kualitas Perairan Kampung Baru Kecamatan Tanjungpinang Barat Kota Tanjungpinang. Skripsi. Jurusan Manajemen Sumberdaya Perairan Fakultas Ilmu Kelautan Dan Perikanan Universitas Maritim Raja Ali Haji

Purnami, A. T., Sunarto. dan P. Setyono. 2010. Study of Benthos Community Based on Diversity and Similarity Index in Cengklik Dam Boyolali. Jurnal Ekosains. 2 (2) : 50 – 65.

Sahami, Femy. 2006. Struktur Komunitas Gastropoda Sebagai Bioindikator Pencemaran Organik di Danau Limboto Provinsi Gorontalo. Jurnal Ilmiah Agrobisnis Tropis (JIAT). Vol.6, No.2 Mei 2011. Hlm 065-070

Saparinto, C. 2007. Pendayagunaan Ekosistem Mangrove. Dahara Prize. Semarang.

Sastrawijaya, 2000. Perencanaan Lingkungan, Penerbit PT Rinika Cipta, Cetakan kedua, Jakarta.

Sha, S. 2010. Epidemiologi : Pencemaran Pestisida. Expert Journal DE L'assainissement. http://herumayrota.blogspot.com. Diakses tanggal 25 Desember 2011.

Simamora, D. R. 2012. Studi. Keragaman Makrozoobentos. Di Aliran Sungai Padang Kota. Tebing Tinggi.

Sinaga, T. 2009*. Keanekaragaman Makrozoobentos Sebagai Indikator Kualitas Perairan Danau Toba Balige* Kabupaten Toba Samosir. Tesis. Sekolah Pascasarjana. Universitas Sumatera Utara: Medan

Suartini, Ni Made. 2005. Keanekaragaman Makrozoobenthos dan Kajian Morfologi Moluska di Danau Beratan dan Tamblingan, Bali. Tesis Sekolah Pascasarjana Institut Pertanian Bogor. Bogor

Sulistiyarto, B. 2008. Keterkaitan Antara Kelimpahan Makrozoobenthos dengan Parameter Fisika Kimia Air di Danau Hanjalantung Palangka Raya Kalimantan Tengah. Fakultas Perikanan, Universitas Kristen Palangka Raya, Kalimantan Tengah

Tanjung, A. 1995. Distribusi Makrozoobenthos di Zona Intertidal Selat Morong Kabupaten Bengkalis Riau. Pusat Penelitian Universitas Riau. Pekanbaru. 27 hal.

Tenribali. 2015. *Sebaran Dan Keragaman Makrozoobentos Serta Keterkaitannya Dengan Komunitas Lamun Di Calon Kawasan Konservasi Perairan Daerah (Kkpd) Di Perairan Kabupaten Luwu Utara*. Skripsi. Jurusan Ilmu Kelautan Fakultas Ilmu Kelautan Dan Perikanan Universitas Hasanuddin Makassar

Ummami, Dea. 2012. *Variasi Spasial Dan Temporal Struktur Komunitas Makrozoobentos Di Daerah Estuari Pantai Mayangan, Jawa Barat*. Skripsi. Departemen Manajemen Sumber Daya Perairan Fakultas Perikanan Dan Ilmu Kelautan Institut Pertanian Bogor : Bogor

Untung, K., S. Noegrahati, S. D Tanjung, B. V. Romer-Seel, B. Widyantoro, S.S. Brahmana, S.Sudaryanti, T. Sudibyaningsih dan Y.Trihardiningrum.1996. Makrozoobentos Sebagai Bioindikator Kualitas Periaran Tawar. Hasil Perumusan Kelompok I Rapat Kerja Temu Pakar Bioindikator LAKFIP-UGM. Yogyakarta. 1-2 Maret.

Yasir, Abdul. 2017. *Struktur Komunitas Makrozoobenthos Pada Lokasi Dengan Aktivitas Berbeda Di Perairan Sungai Tallo Kota Makassar.* Departemen Ilmu Kelautan Fakultas Ilmu Kelautan Dan Perikanan Universitas Hasanuddin Makassar

Zahidin, M. (2008). *Kajian Kualitas Air Di Muara Sungai Pekalongan Ditinjau Dari Indeks Keanekaragaman Makrobenthos Dan Indeks Saprobitas Plankton*. Semarang: Universitas Diponegoro. Zahidin, M. (2008). Kajian Kualitas Air Di Muara Sungai Pekalongan Ditinjau Dari Indeks Keanekaragaman Makrobenthos Dan Indeks Saprobitas Plankton. Semarang: Universitas Diponegoro.