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# IDENTIFICATION AND DIVERSITY OF ORGANISMS IN THE LAKE TOBA AREA

**R. E. Lubis*[1], M. H. Irawaty[2], Ibrohim[3], S. E. Indriwati[4]**

[1]Graduated Program of Biology Education, Universitas Negeri Malang, Indonesia
[2,3,4]Biology Education Departement, Universitas Negeri Malang, Indonesia

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**ABSTRACT**

This research is an explorative research/Land-Based Survey. The purpose of this research is to identify an organism in the Lake Toba water to see organism diversity in the area of Lake Toba, and some factors which influence the kind and diversity of organism in Lake Toba. This research was conducted by using methods of a trap in May 2016 until April 2017 in three regencies of Lake Toba Area, including Samosir, Simalungun, and Porsea Regency. The result of the research showed that the organisms found in the waters of Lake Toba were Plakton, Macrozoobentos, and Nekton. The index of macrozoobenthos diversity in three regencies are categorized into low. The highest value of diversity was in Samosir Regency (1,6) then followed by Tobasa (1,5), and Simalungun (0,43). The value of plankton diversity index in three regencies are; Samosir (2,47), Tobasa (1,41), and Simalungun Regency(1,63). The index of fish diversity in three regencies was categorized into low; Samosir (1,97), Tobasa (1,16), and Simalungun Regency (1,61). In those three districts, there were 25 species of plankton, 12 species of macrozoobenthos and 8 species of fish. The change of the environmental condition influenced the diversity of animal. The research suggests that the need for conservation as the management planning to cope with the environmental condition to maintain the quality of Lake Toba environment.



Keywords: diversity, Lake Toba, organism

## INTRODUCTION

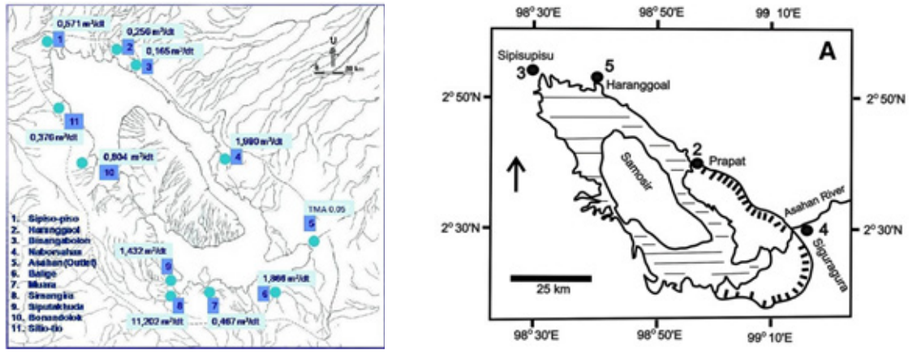
Lake Toba is one of the largest lakes in Indonesia with the type of volcano-tectonic lake. The explosion of Toba volcano (tumor Batak) formed Lake Toba. It located in the coordinates of 2010'N-300'N and 98020" E-99050"E or in the Bukit Barisan mountains of North Sumatra Province. The Lake Toba area consisted of seven districts, namely North Tapanuli Regency, Humbang Hasundutan, Toba Samosir, Samosir, Simalungun, Karo, and Dairi (Siregar, 2008). The area of Lake Toba is 1,124 km2 with a maximum depth in the northern concave section (508 m) while the southern concave maximum depth is 420 m (Lukman et al., 2012).

Lukman et al.,( 2012) stated that the water of Lake Toba comes from rainwater and rivers flowing into the lake. The pattern of water flow is dominated by inlets from small rivers which is 289 rivers and only 71 permanent rivers, and others are seasonal. The outline of the Lake Toba water flow originates only from the Asahan River, which empties into the East Coast of Sumatra (figure 1a).

The environmental problem in the Lake Toba area is currently becoming a national issue. Environmental quality in the Lake Toba area is

***Correspondence Address**
E-mail: retnitalubis@gmail.com

decreasing due to the environmental damage and pollution as well as community activities such as settlements, agriculture, plantations, hotels, fisheries, industries and others (Siregar, 2008). The decreasing of Lake Toba water quality will impact on the human, animal, plant, and natural resources, that can reduce the number of animal and population of the plant.




(a) (b)

**Figure 1.** a. Lake Toba Inlet Map (Rustini et al., 2014); b. Toba Caldera (Westgate, 2014)

Nutrient levels influence the decline in the water quality of the Lake Toba which are currently high(Sitanggang, 2013; Barus, 2004; Nomosatyo & Lukman et.al, 2013; Lukman et al., 2012; Nomosatryo & Lukman, 2012; Sinaga, 2009; Siagian, 2009; Fitra, 2008; Widhiastuti, 2008). The increase in nutrient characterized by TP (Total Phosphor) levels in the waters of Lake Toba that influenced nutrient sources for food availability such as plankton, especially phytoplankton. Only a few types of organisms can live in the lake such as plankton due to the nature of the lake, which is oligotrophic. Increased levels of TP in the waters of Lake Toba impacts on the changes of waters to be trophic so that various organisms can inhabit there because the resource requirements (nutrients) are sufficient. The increase of nutrients in the waters of Lake Toba results in changes in the condition of the waters from oligotrophic to trophic even it is going to mesotrophic(Nomosatryo & Lukman, 2012; Lukman et al., 2012).

One of the ways in utilizing Lake Toba is by Developing fish cultivation with Karamba Jaring Apung (KJA) or Floating Net Cages. That activity influences the trophic status of Lake Toba waters. The simple indicator for determining it is by looking at the Total Nitrogen and Total Phosphor. Total phosphor is used empirically to predict the algal biomass because of its role in the limiting factor. In 2009 the availability of TN and TP nutrients in Lake Toba has produced trophic status from oligotrophic to eutrophic, whereas if it showed from the abundance parameters of chlorophyll-a and Secchi depth, the waters of Lake Toba were still oligotrophic (status clarification based on the Carlson composite index (TSI), clarification of trophic status based on a composite index illustrates the production process of a lake because it was related to nutrient availability which produced abundance of biological indicators.

Based on the above explanation, the purpose of this study is to identify the organisms in Lake Toba water, to see the diversity of organisms in the Lake Toba Area, and the factors that influence the diversity of organisms in the Lake Toba Area.

## METHODS

The study was conducted in May 2016 until April 2017. The research location was in three districts of Lake Toba Area, namely Samosir, Simalungun and Porsea Regencies. Sampling was carried out by several methods of trapping traps, namely fishing nets, plankton net, and stratified sieves.

### Fish Catching

Fishing was done using fishing nets. Installation of this net was done twice for two days, in the morning and evening. The morning installation started at 8:00 a.m. and finished at 4:00 p.m., and the evening installation was done at 6:00 p.m. and finishedat 5:00 p.m. This means that fish sampling follows the fishing schedule by the fisherman. The fishing installation nets was carried out at a distance of 10 meters from the edge of the waters.



### Plankton Sampling

Plankton sampling was carried out horizontally using a plankton net. Horizontal plankton sampling was done by throwing the plankton net at a predetermined distance, then pulling the plankton net toward the researcher horizontally. Horizontal sampling was intended to obtain plankton on the surface of lake waters. This sampling was done three times with a distance of 5 meters, 10 meters, and 15 meters.

### Macrozoobenthos Sampling

Taking the samples of macrozoobenthos was done by sorting the sediments on the edge of the lake with stratified sieves. This sampling was done three times taking, which was at a distance of 5 meters each point.

### Measurement of Environmental Factors

Taking the samples of macrozoobenthos was done by sorting the sediments on the edge of the lake with stratified sieves. This sampling was done three times taking, which was at a distance of 5 meters each point.

The entire sample that has been obtained was identified at the Laboratory of Medan State University. Sample identification using Lukman et al. (2012). Analysed by measuring the diversity index and similarity index, using the following formula;

***Shanon Diversity Index (Shannon-Wiener index)***

$$H = -\sum pi \ln pi \text{ with, } pi = \frac{ni}{N} \text{ or}$$

$$H = -\sum_{i01}^{s} (pi)(\log pi)$$

Information:
H = species diversity; Pi = species interest per species total interest; ni = number of individuals or biomass of species *i* found in the community; N = the total number of individuals or biomass of the whole species in the community

Criteria:
0 <H ‘<2.3 = Low diversity; 2.3 <H ‘<6.9 = Medium diversity; H ‘> 6.9 = High diversity

**Table 1.** The Degree of Pollution

| Diversity Index (H) | Degree of Pollution |
|---|---|
| 2.0 | not polluted |
| 1.6-2.0 | slightly polluted |
| 1.0-1.6 | fairly polluted |
| 1.0 | heavily polluted |

***Uniformity Index***

$$E = {}^{H}/_{\ln S} \text{ or } J' = {}^{H'}/_{H'_{max}}, \text{ in which}$$

$$H'_{max} = \log k$$

Information:
E = evenness(the value of E ranges between 0-1 (Yazwar, 2009 in Michael, 1984); S = number of species; J‘ = equitability index; H‘ = Shannon diversity index; k = number of taxon

Criteria:
0 E 0,4 = Low uniformity; 0,4 E 0,6 = Medium uniformity; E 0,6 =High uniformity

***Similarity Index (SI)***

$$SI = \frac{2c}{a+b} \times 100\%$$

Where:
a = Number of species at station; b = Number of species at station B; c = The number of same species at stations A and B

Criteria:
75-100% = very similar; 50-75% = similar; 25-50% = not similar; 25% = very not similar (Michael, 1994 in Siagian (2009)

## RESULTS AND DISCUSSION

The result of environmental factors measurement is that the temperature in the water of Lake Toba for three districts, namely, Simalungun, Tobasa and Samosir Regencies range at of 26o-28oC with a pH range 6. The temperature and pH range of Lake Toba allows aquatic organisms to life optimally. Community activities in the three regencies in the form of Karambah Jaring Apung (KJA) which is one of their livelihoods in the waters of Lake Toba.

With its condition, several types of organisms can live such as plankton, macrozoobenthosans fish. In those three districts they were 25 genera of plankton, 12 species of macrozoobenthos and 8 species of fish (Table 2, Table 3 And Table 4). Diversity index in each district was range from low to medium, while the uniformity index ranged from low to high (Figure 2).

The diversity index value of orgamisms in three districts ranged from 0.43 to 1.64 and the similarity index is at 0.39-0.91 (Figure 2). Every year the diversity index value and the similarity index of living things in the Lake Toba Area are fluctuating so that it affects the number of organisms species in the waters of Lake Toba. This is due to changes in the environment by the level of pollution of lake waters by KJA activities.

**Table 2.** Macrozoobenthos Species that are Found in the Waters of Lake Toba

| No | Type of Makrozoo-bentos | Location | | |
|---|---|---|---|---|
| | | Samosir | Tobasa | Simalungun |
| 1 | Corbiculidae | √ | √ | - |
| 2 | Sphaeriidae | √ | - | - |
| 3 | Caenogas-tropoda | √ | - | - |
| 4 | Buccinidae | √ | √ | - |
| 5 | Thiaridae | √ | √ | - |
| 6 | Viviparidae | √ | - | - |
| 7 | Anodonta | - | √ | √ |
| 8 | Elimia | - | √ | √ |
| 9 | Melanoides | - | - | √ |
| 10 | Pila | - | √ | - |
| 11 | Anentome | - | √ | - |
| 12 | Litoridinops | - | √ | - |

Macrozoobenthos found in the waters of Lake Toba varies greatly in three districts (Table 1). Several types of macrozoobenthos were found in each district and some were only found in certain districts. For example, types of Corbiculidae, Buccinidae and Thiaridae were found in Samosir and Tobasa Regencies. Types of Anodonta and Elimia were found in Tobasa and Simalungun Regencies. Tobasa Regency has more variety types.

Water of Samosir Regency tend to be muddy that tend to be muddy even though in some places are sandy and mud-sandy. Tobasa and Simalungun districts are generally sandy and rocky. Generally the Gastropod groups can live on rocky substrates, sandy until muddy and have a very wide spread. The research conducted by Sinaga in 2009 showed that gastropods were found in almost every research station, because the research stations were generally muddy sand. The types of macrozoobenthos encountered during the study were many from the gastropod group.

**Table 3.** Types of Plankton that are Found in the Waters of Lake Toba

| No | Type of Plankton | Location | | |
|---|---|---|---|---|
| | | Samosir | Tobasa | Simalungun |
| | **Phytoplankton** | | | |
| 1 | Cymbella | √ | - | √ |
| 2 | Rhopalodia | √ | - | √ |
| 3 | Pediastrum | √ | - | √ |
| 4 | Volvox | √ | - | √ |
| 5 | Docidium | - | - | √ |
| 6 | Isthmia | √ | - | √ |
| 7 | Euglena | √ | - | √ |
| 8 | Synedra | √ | - | √ |
| 9 | Ulotrix | √ | - | √ |
| 10 | Staurastrum | √ | - | √ |
| 11 | Tribonema | √ | - | √ |
| 12 | Spirogrya | √ | - | √ |
| 13 | Chlorella | √ | - | √ |
| 14 | Staurodesmus | - | - | √ |
| 15 | Planothidium | √ | - | √ |
| 16 | Thalassiosira | - | √ | - |
| 17 | Anabaena | - | √ | - |
| 18 | Closterium | - | √ | - |
| | **Zooplankton** | | | |
| 19 | Gloeocapsa | √ | - | √ |
| 20 | Peridinium | √ | - | √ |
| 21 | Ceratium | √ | - | √ |
| 22 | Trichocerca | √ | - | - |
| 23 | Metidae | √ | - | - |
| 24 | Femoridae | √ | - | - |
| 25 | Cylindropsyllidae | √ | - | - |

The types of plankton found in the waters of Lake Toba were very diverse in the three districts (Table 3). Several types of plankton were found in each district and some were only found in certain districts. For example, zooplankton in each district has many different types except dinophyceae that were found in Tobasa and Simalungun. Simalungun Regency has more varieties of plankton types.

**Table 4.** Fish Species in the Waters of Lake Toba

| No | Type of Fish | Location | | |
|---|---|---|---|---|
| | | Samosir | Tobasa | Simalungun |
| 1 | *Cyprinus carpio* | √ | √ | √ |
| 2 | *Osteochilus hasselti* | √ | - | - |
| 3 | *Mystacoleucus padangensis* | √ | √ | √ |
| 4 | *Oxyeleotris marmorata* | √ | - | √ |
| 5 | *Channa striata* | √ | - | √ |
| 6 | *Oreochromis mossambica* | √ | √ | √ |
| 7 | *Oreochromis niloticus* | √ | √ | √ |
| 8 | *Clarias batrachus* | √ | - | - |



The types of fish found in the waters of Lake Toba vary greatly in the three districts (Table 4). Several types of fish were found in each district and some are only found in certain districts. For example, types of Cyprinus carpio, *Oreochromis sp*and *Tilapia mossambica*were almost found in all Lake Toba Area. Tobasa Regency has more variety of fish species. Search results from Wijopriono et al. (2010) found 11 species of fish that were often caught by fishermen, such as *Tor duoronensis* (ikanbatak), *Hampalamacrolepidota* (hampala), *Oreochomismossambicus* (mujair), *Oreochromisniloticus* (nila), *Channastriata* (hampal), *Oreochomismossambicus* (mujair), *Oreochromisniloticus*(tilapia), *Channastriata* (gabus), *Oxyyeleotrismarmorata* (betutu), *Clariasbatrachus* (lele), *Cyprinuscarpio* (mas), *Barbodesgonionotus* (tawes), *Anabas testudineus* (betok) and *Mystacoleucuspadangensis* (bilih).

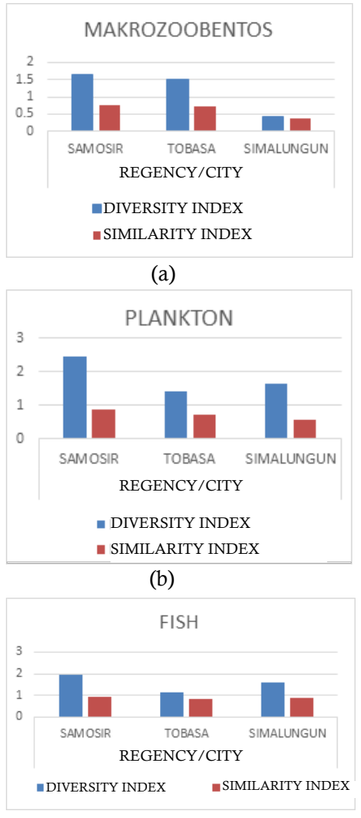



**Figure 2.** Diversity and Similarity Index of Organisms (a. Macrozoobenthos; b. Plankton; c. Fish) Discovered in the Waters of Lake Toba

Figure 2 explains that there are three types of organisms that inhabit the waters of Lake Toba, namely, plankton, makrozoobentos and fish in three districts in the Lake Toba Area. The search results show the level of diversity index and the similarity of organisms found in each district is not the same, for example in Samosir Regency, the plankton diversity index is found in a moderate position while in the two other districts, namely Simalungun and Tobasa, the diversity index tends to be low. Makrozoobentos and fish found in three districts have low diversity index. The high similarity index for the living things was in Samosir Regency, while index for of living things in Simalungun Regencyis in low to moderate level.

Samosir Regency has the highest diversity and similarity index, this shows that the location is relatively natural and good for the organisms growth and shows that there is no species that dominates and the individuals spread equally. Widhiastuti (2008) explains the high diversity index in a location allows for the growth of organisms and that location was still relatively natural which has not contaminated by pollution, the distribution of individuals that are close to even or not indicate the existence of species that dominates. Siagian (2009) explained the high diversity index in a location showed that food sources in those locations were more complex than other locations and the high similarity index in a location illustrates the distribution of living things or the degree of a species dominance and ecosystem stability.

**Table 5.** Similarity Index (%) Macrozoobentos Community between Districts in the Lake Toba Waters (Samosir, Tobasa, and Simalungun)

| Regency/ City | Samosir | Tobasa | Simalungun |
|---|---|---|---|
| Samosir | - | 30.76% | 30% |
| Tobasa | | - | 50% |
| Simalungun | | | - |

Table 5 describes the macrozoobenthos community in the three Regencies having similarities, but in Tobasa and Simalungun Regencies there are differences in the macrozoobenthos community.

**Table 6.** Similarity Index (%) Plankton Community between Districts in the Lake Toba Waters (Samosir, Tobasa, and Simalungun)

| Regency/ City | Samosir | Tobasa | Simalungun |
|---|---|---|---|
| Samosir | - | 8.69% | 91% |
| Tobasa | | - | 8% |
| Simalungun | | | - |

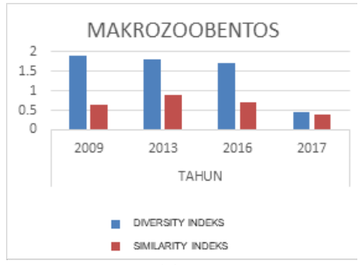
Table 6 explains the plankton community in the three districts is very different. The highest level of similiity is in Samosir and Simalungun Regencies, meaning that the communities in both Regencies have similarities.

**Table 7.** Similarity Index (%) Fish Community between Districts in the Lake TobaWaters (Samosir, Tobasa, and Simalungun)

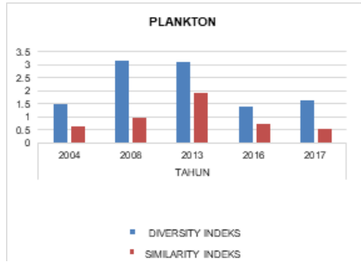
| Regency/ City | Samosir | Tobasa | Simalungun |
|---|---|---|---|
| Samosir | - | 66.67% | 86% |
| Tobasa | | - | 80% |
| Simalungun | | | - |

Table 7 explains that in general the fish communities in the three Regencies have similarities.

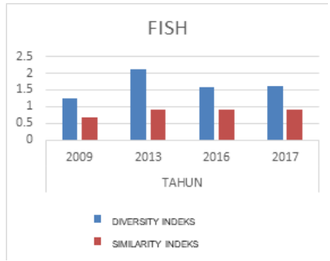
The level of similarity in the aquatic organisms of Lake Toba is influenced by the physical-chemical properties of the waters. Yazwar (2008) explained that although the physical-chemical properties of the research sites differed from each other, but in the formation of the community of Lake Toba's orgamism it seemed to have relatively no significant effect. Sinaga (2009) stated that relatively homogeneous microsites were occupied by individuals of the same type, because these species naturally have developed mechanisms for adaptation and tolerance to their habitat. The greater the similarity index values the more the same type in different locations.




(a)




(b)




(c)

**Figure 3.** Index Comparison of Living Things (a. Makrozoobentos; b. Plankton; c. Fish) Diversity and Similarity found in the Lake Toba Waters

From the result of the research (Figure 3), the diversity index of living things in the Lake Toba was moderate while the similarity index was low to high. It was found that the diversity index of macrozoobenthos tends to decrease, while plankton and fish experiences up and down every year. The up and down of the diversity and similarity indexes of living things in Lake Toba illustrates the rise and fall of the nutrients availability and the use of nutrients in living things in Lake Toba waters every year. Widhiastuti (2008) explained that the nutrients availability and the use of different nutrients caused the diversity and uniformity index become various. The availability and the use of nutrients by living things in the waters of Lake Toba is influenced by the level of waters pollution. The pollution level in the Lake Toba waters has a different effect to every living thing. The higher the level of pollution in a location causes the lower the level of living things diversity. The up and down index of living things diversity in the Lake Toba waters each year is caused by water pollution which changed the environment.

Lake Toba is a kind of Oligotrophic nature, in which the lake waters have poor nutrient and are only inhabited by plankton. Wijopriono et al. (2010) argued that the changing of tropical status of Lake Toba waters was caused by the declining quality of lake water that occurred during the past seven decades. The source of water at Lake Toba comes from the inlet and outlet of the rivers that surround it, so that most of the organisms in Lake Toba come from river waters. A similar sentiment was conveyed by Kartamihardja (2012) which stated that some of the fish species in lakes and reservoirs are generally river dwellers.

The macrozoobenthos diversity index in the three districts, Samosir, Tobasa, and Simalungunis was the highest diversity index. It was in Samosir District (1.6), Tobasa (1.5), and Simalungun (0.43) see Figure 2. Base substrate in the three different districts is that Samosir District is generally muddy-sand substrates, Tobasa District is Stone-sanded, and Simalungun is sandy. The substrate greatly influences the presence of macrozoobenthos (Lubis, 2013; Wahyuni, 2014). Sinaga (2009) described areas where the basic substrate is sangan rock which supports the life of macrozoobenthos. Samosir has the highest diversity index since the waters in Samosir have an abundant food source for macrozoobenthos. As explained by Sitanggang et al. (2013) food availability (biotic factors) supports the existence of macrozoobenthos. Muddy sandy Samosir allows for the accumulation of food availability for macrozoobenthos. In addition, the main environmental factors affecting the diversity of macrozoobenthos are temperature, transparency, dissolved oxygen, depth and pH of water (Hu et al., 2018).



Mushthofa et al. (2014) explained that a calm environment allows the deposition of mud followed by accumulation of organic matter in which it can be originated from increased activity on land. Zang et al. (2019) explained that macrozoobenthos has an important role in freshwater because it can decompose organic matter at the bottom of the water and is also a food source for fish. Hanson et al. (2012) explain the presence of fish in a waters influencing the type of macrozoobenthos community and positively related to the abundance of plants in the waters.

The macrozoobentos uniformity index in the three districts was low to high where Samosir (0.74), Tobasa (0.73), and Simalungun (0.39). If the uniformity index value was close to 1 then it has high similarity and there was no type that dominates, while the uniformity index close to 0 was low in its similarity. The uniformity index that close to the maximum value has a good macrozoobenthos population distribution, showed by many types of macrozoobenthosthat found in that location (Sinaga, 2009; Lubis et al., 2013; Sitanggang, 2013; Mushthofa et al., 2014; Wahyuni, 2014). The number of genus found in Samosir Regency was 9 genus with 340 individuals and distributed equally while Simalungun Regency found 3 genus and the number of individuals amounted 97 with Emilia as the genus that dominates. Jayanti et al. (2018) explains the community that dominates a waters indicates that the waters are polluted, and macrozoobenthos is a bioindicator for water pollution.

Plankton diversity index values in the three districts, i.e Samosir Regency (2.47), Tobasa (1.41), and Simalungun (1.63) were in low-medium (Figure 1). The lowest diversity index was found in Tobasa Regency and the highest was in Samosir Regency.This shows the type and number of individuals found in Samosir Regency more than other districts. Barus (2004) explains that the low plankton diversity index in a location shows the types and individuals of plankton found was low and this causes only a few species of fish to live in that location. The high value of the diversity index in Samosir Regency shows that this location was suitable for plankton to grow, as explained by Widhiastuti (2008), the value of the high diversity index in a location showed that the location was good for plankton growth. If it is related to the level of pollution, the condition of the Lake Toba waters in the three regencies was in the uncontaminated condition which is moderately polluted.

Hemraj et al. (2016) explained that water quality greatly influences the structure of the plankton community. Plankton play a role in the nitrogen cycle and its response to changes in environmental factors in freshwater ecosystems (Sun, 2014).

The plankton uniformity index in the three districts was high, Samosir (0.89), Tobasa (0.73), and Simalungun (0.56). The high value of uniformity index in Samosir Regency allows enough sources of nutrition for plankton growth, as explained by Widhiastuti (2008)if the uniformity index in a location was high, it can be caused by the availability of sufficient nutrients (phosphate, nitrate and ammonia) for the spread of plankton. At least the difference in the uniformity index of the plankton population in the three districts showed the uniformity of plankton abundance in the plankton community. Sagala (2012) explained that if there was a difference in the plankton diversity index value in several research locations, it can be assumed that the abundance of each species in the community was almost uniform and there was no dominant species. The number of genus found in Samosir Regency was 16 genus and 5056 ind / L, Tobasaamounted 7 genus with 39 ind / L, and Simalungun 19 genus with 22893 ind / L.

The fish diversity index in the three districts was low, i.e in Samosir Regency (1.97), Tobasa (1.16), and Simalungun (1.61) see figure 1. Sinaga (2009) stated the diversity index value in Samosir Regency was classified as low.The low diversity index according to Tarigan (2013) will result in the number of individuals in each species found uneven. Low fish diversity was causing by polluted environmental factors. The pollution of Lake Toba waters was caused by the large

amount of sediment deposits and other chemical factors. This will result in disruption of fish habitat and can affect the function of organisms in the ecosystem. As explained by Shuai et al. (2017) chemical factors such as DO, water clarity, NH4-N concentration and TDS will influence fish to find food. Consistent habitat will affect the role of organisms in the ecosystem.

Fish uniformity index in the three districts was high, Samosir Regency (0.95), Tobasa (0.84), Simalungun (0.89). The uniformity index shows the distribution of fish density in the ecosystem while the fish caught is used as an illustration of type and ecosistem balance domination level (Siagian, 2009; Tarigan et al., 2013). This proves that uniformity of fish in the three districts was stable. Generally, the types of fish found in the three districts come from the genus cyprinidae and oreochromis. Kartamihardja (2012) explains that lake-dwelling fish and reservoirs are generally cyprinis families such as hampala, puntius, barbonymusmystacoleucus, and osteochilus; silurid families such as mystus, channa; and the chiclids and oreochromis family.

The similarity index of living things in the Lake Toba waters in the three districts shows that the macrozoobentos community in the three districts has no similarity. The plankton community between Samosir and Simalungun Regencies is very similar and the plankton community between Samosir and Tobasaalso Tobasa and Simalungun Regencies has no similarity, fish community the three districts have similarities especially between Samosir and Simalungun Districts and Tobasa and Simalungun Districts that have very similar fish communities (see tables 4.5, and 6). Different research locations, but considered as one community, although the research locations are different and have different chemical-physical properties, in the formation of living things communities in the Lake Toba waters it seems relatively ineffective (Widhiastuti, 2008).

The low diversity index and the uniformity index of living things in the Lake Toba waters were caused by waste in the environment. Environmental waste in lake waters is influenced by physical-chemical properties, such as temperature, pH, organic matter, inorganic substances, salinity, and others. . Afonina & Tashlykova (2018) stated the temperature of water, minerals, and pH, the main factors for determining the abiotic and biotic components of a waters. Based on the results of the diversity index of living things calculation (figure 1) the waters of Lake Toba are in the condition of mild to moderate conditions. The results of temperature measurements at the researchlocated in three districts, the average temperature obtained was 260c to 280c. The temperature range is generally the temperature of the waters for the tropics (Barus, 2004 & Tarigan et al., 2013), and in general the temperature range is normal for the growth of living things in the waters (Sinaga, 2009).

Measurement of acidity (pH) in lake waters obtained pH 6, low pH levels baused by society activities that dispose the waste in the Lake Toba waters. As Tarigan et al. (2013) explained the low pH in the research location is because the large number of society activities that dispose the waste to that location, and the pH range is still at the limit for tropical waters and supports the life of water living.

Lukman et al. (2012) explained in the observation in 2009, the pH of Lake Toba waters tended to be alkaline (> 7), low turbidity (<3 NTU) and conductivity between 0.154-0.162 mS / cm, the conductivity level of Lake Toba waters is in the medium range. Tarigan et al. (2013) explained the high value of turbidity in the research location because of the accumulation of waste from many activities from upstream to downstream and caused by waves from the lake so that mud particles were raised and caused in high turbidity. Another factor that influences the decrease of Lake Toba water quality is the current rate because it can predict patterns of spreading waste and spatial distribution of water quality (Rustini et al., 2014). Barus (2004) explained that when the temperature of a waters increases, the oxygen solubility will decrease and vice versa, therefore especially for aquatic ecosystems in the tropics which generally have relatively high temperatures will have limitations in absorbing oxygen. Ramos-Jiliberto et al. (2009) stated the low variation of organism in the water of the lake were not only caused by chemical factors, physics, and biology, but the age foor water body of the lake waters also caused the lack of organism in the lake area, especially the plankton community.

The research resulted that diversity index and similarity indeks of plankton were different each year (figure 3), there were fluctuation in diversity and similarity indexes that influenced by the environmental pollution. The occurrence of sedimentation of phosphate content from the remaining fish feed in the KJA greatly influences it. In 2016 the Lake Toba washit by a long dry season, so that the remaining food sediments of the fish that were leftarose to the water surface and became toxic to organisms in the lake. This is indicated by the large amount of dead fish, especially fish in KJA.



The variation in the organisms number in the Lake Toba water is located in three Regencies. Simalungun, Tobasa and Samosir was influenced by the quality level of Lake Toba waters that decreased. The decrease of lake waters quality was influenced by some factors, one of them is society activities. The biggest society activity in the lake waters was KJA (Floating Net Cages) which was the livelihood of most people who live around Lake Toba.

Irregular KJA activity resulted sedimentation in the bottom of water because of the accumulation of fish food residues that were not digested by fish. This sedimentation caused nutrients in the waters of the lake becomes high. The increase in nutrients in the waters of the lake caused the status of Lake Toba was extending from oligotrophic, mesotrophic to eutrophic (Nomosatryo & Lukman, 2012). The changes of Lake Toba status was affected by the TP and TN values of the lake waters. TP and TN values in the waters of Lake Toba were high (Nomosatryo, 2011). TP level in the waters of Lake Toba doesn not become a source of nutrients available for phytoplactons so that its abundance was low and show trophic status of lakes in oligotrophic to mesotrophic conditions (Lukman et al., 2012). Strayer & Dudgeon (2010) explained that dissolved nutrients in waters have a large effect on algal growth, but also have an indirect effect on fish.

The KJA activities spread on the sides of Lake Toba are owned by the society, even though most were also owned by foreign companies. KJA owned by foreign companies is well arranged, usually containing not only fish, freshwater lobster is also part of the development of the KJA. The society KJA is generally well arranged and only contains fish. There are 50 villages/ hamlets that have KJA activities with a total of 5,158 society-owned KJA units and 72 units and 5 locations belonging to a Foreign Capital Company (Lukman et al., 2012).

It is not planned that the planning arrangement of KJA that is not prevalent has resulted the conditions in the waters of Lake Toba get worse. It can be seen in table 3, the type of fish that lives in the Lake Toba waters is decreasing and only fish with economic value can live well in the waters of Lake Toba. The type of fish that is an icon of the waters of Lake Toba has been difficult to find. Not only do fish species decrease its number, but also plankton and macrozoobenthos.

Lukman et al., (2012) stated that KJA zoning determinationin of Lake Toba needs to consider several things, i.e: a) hydromorphometric factors and patterns of mass flow of water in lake waters; b) littoral area of the lake; c) the length of the coastline of each Regency; d) agricultural land area of each Regency; e) number of local residents; f) business and port activities; g) tourism area and tourism potential; h) fish reserve area; and i) main drinking water in take area.

The research on organism diversity in Toba Lake Area will be unlimited. Still there are many things to explore to be the research materials for further research. The research in the field of life environment is needed to be increased in Toba Lake Area because the environmental factor highly influences the organism diversity. Beside as the center of tourism in North Sumatra, Toba Lake Area is the place to work for a living for the society, until it influences the quality of the lake water especially the activity related to the fish which becomes the source of people livelihood. This activity has influence on the quality of the water in the lake nowadays.So, there is a need for further research in a sustainable manner in looking for factors that affect the declining quality of lake waters especially in the physical-chemical factors of lake waters.

## CONCLUSION

There were three types of organisms in the waters of Lake Toba, i.e macrozoobenthos, plankton, and fish. Macrozoobentos found in Samosir Regency were found 9 genera, Tobasa 17 genera, and Simalungun 3 genera. Plankton found in Samosir Regency there are 16 genera, 7 genera Tobasa, and 19 genera Simalungun. There are 8 species of fish found in Samosir Regency, 4 species of Tobasa, and 6 species of Simalungun.

The fiversity index of makrozoobenthos in three regencies was categorized into low around 0,43 until 1,64 and its uniformity index was categorized into medium until high around 0,39 – 0,74. Diversity index of plankton was categorized into low until medium 1,41 – 2,47, and its uniformity index was categorized into medium until high 0,56-0,89. The diversity index of fish was categorized into low 1,16-1,97, and its uniformity index was categorized into high 0,84-0,95. Similarity index of bentos community between Tobasa Regency and Simalungun Regency was similar, the similarity index of plankton community between Samosir Regency and Simalungun Regency was very similar, and similarity index among those three regencies are very similar.The factors which influence organism diversity in the waters of Toba Lake was environmental pollution. The biggest contribution of environmental pollution in the waters of Toba Lake was from waste disposal by the society and the activity of KJA which mostly done in the waters of Toba Lake.

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