Indonesian Journal of Limnology
Vol. 04 No. 02, 2023 (45-60)
E-ISSN :2774-2571

Phytoplankton Composition and Water Fertility Status of Lake Ranau, West Lampung Regency, Lampung Province

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Received 02 November 2023 Accepted 02 February 2024 Published 04 February 2024

DOI: 10.51264/inajl.v4i2.42

Abstract

Lake Ranau is the second largest lake on Sumatra Island. This lake has a high potency for fisheries. Fisheries activities carried out in Lake Ranau are fishing and aquaculture activities with nile tilapia (*Oreochromis niloticus*) as the main commodity. Intensive fish farming activities will cause impacts in the form of waste caused by feces and wasted feed. This waste will increase the nutrient loads that enter the waters, triggering the nutrient enriching phenomenon known as eutrophication. Eutrophication is a process of water enrichment by nutrients, mainly nitrogen and phosphorus, which can change the community structure of phytoplankton in the waters and increase their growth. This study aims to analyze the composition of phytoplankton in the waters of Lake Ranau and to estimate the status of water fertility. Data collected was water quality data and phytoplankton data. Status of water fertility was analyzed using the saprobic index. The results show that the community structure of phytoplankton exhibits values as follows: the diversity index ranging from 1.54–3.08, the uniformity index ranging from 0.46–0.90, and dominance index ranging from 0.06–0.41. The abundance of phytoplankton is dominated by the species *Nitzhia* sp., *Synedra*, *Diatoma*, and *Tabellaria* (all are from the Bacillariophyceae class). The saprobic index obtained ranges from 0.74–1.26, thus categorized as the β/α-mesosaprobic phase, meaning the waters of Lake Ranau are lightly polluted by a little load of organic and inorganic matters.

Keywords: Aquaculture, Bacillariophyceae, Fisheries, Saprobic, Water fertility.

1. Introduction

Lake Ranau is the second largest lake on Sumatra Island, formed by tectonic and volcanic processes. This lake is located on the border of West Lampung Regency, Lampung Province and South Ogan Komering Ulu (OKU) Regency, South Sumatra Province. Lake Ranau covers total area of 125.9 km^2. An area of 84.23 km^2 is situated in the Banding Agung subdistrict of South OKU, South Sumatra, and an area of 41.67 km^2, is situated in the administrative area of West Lampung Regency, Lampung (Nontji, 2016). Lake Ranau is utilized by the surrounding community as a tourism destination and place for fisheries activities, such as fishing and aquaculture.

The potential fish production in Lake Ranau is known to continue to increase, at 22.32 tons/year (Subagja et al., 2013) and in 2019 (75.84 tons), 2020 (96.5 tons), and 2021 (260.59 tons) (Ministry of Marine and Fishery, 2023). Reared fish are dominated by large-sized sebarau fish, medium-sized kemencut fish, and arongan fish (which are genetically refer to the same species, namely *Hampala macrolepidota*) (Makmur et al., 2014), mujair (Oreochromis mossambicus), kepor (*Pristolepis grotti*), palau (*Osteochilus vittatus*), and tilapia (*Oreochromis niloticus*). In addition to reared fisheries production, aquaculture activities in Lake Ranau have started to develop. Aquaculture activities are mostly centered in the Lumbok Seminung area, with tilapia as the main commodity. Aquaculture using floating net cage (FNC) system in Lake Ranau can make West Lampung Regency the largest freshwater fish producing region in Lampung Province (Primus, 2010).

Rearing or aquaculture fisheries in Lake Ranau often experience problems in the form of mass fish death that routinely occurs every few years. Ministry of Energy and Mineral Resources (2011) and Setyahadi et al. (2012) noted that the phenomenon of fish death in Lake Ranau in large numbers had occurred several times, namely in 1962, 1993, 1995, 1998, 2009, and 2011. The mass fish death also occurred in fish farmed in FNC. This happened in February 2018 (Eliyah, 2018; Yasland & Murdaningsih, 2018), and most recently in January 2023 (Azizah, 2023).

Mass fish death also occurred in several lakes or reservoirs in other regions in Indonesia, such as Lake Maninjau, Lake Toba, Lake Singkarak, Wadaslintang Reservoir, Gajah Mungkur Reservoir, Cirata and Jatiluhur Reservoirs, Kedung Ombo Reservoir, and Saguling Reservoir. The mass fish death in Lake Ranau was thought to be caused by high H_2S gas produced by volcanic activity (Zaennudin et al., 2011; Nontji, 2016). Meanwhile, the mass fish death in other lakes or reservoirs was thought to be caused by the phenomenon known as water mass reversal (Widyastuti et al., 2009; Kartamihardja, 2013; Coubout, 2015; Kartamihardja & Krismono, 2016). The reversal of water mass, namely a phenomenon where the deeper part of waters rises to the surface or upper part of waters, often brings out toxic compounds, such as NH_3, H_2S, and decrease the dissolved oxygen so that it cause fish death. These toxic compounds are resulted by aquaculture waste. Waste from FNC activities in the form of fish feces and remaining wasted feed often results in nutrient enrichment phenomenon known as eutrophication (Aida & Utomo, 2012; Zulfia & Aisyah, 2013; Alvarez-Vazquez et al., 2014; Nontji, 2016). In high amounts, excess nutrients settle to the bottom of the waters, potentially becoming a source of toxicity for fish in the surface when the water mass reversal occurs.

This process of water mass reversal can strongly alter the physical and chemical conditions of the waters, including affecting the biological processes of bacteria and phytoplankton in the waters (Troitskaya et al., 2015). Nutrients in the form of nitrogen (N) and phosphorus (P) elements affect microorganisms, especially phytoplankton. Phytoplankton is an organism that is sensitive to changes in nutrients, such as N and P elements (Eddy, 2016). Excess nutrients also increase phytoplankton growth and can lead to poor ecological status of waters (Zulfia & Aisyah, 2016). Phytoplankton plays important roles in an aquatic environment, one of which is as an indicator of water quality.

Water quality monitoring often uses phytoplankton as an indicator. El-Serehy et al. (2018) determined water fertility by using the trophic status index method based on phytoplankton abundance or chlorophyll-a content. This method was also used by Subagdja et al. (2013) and Muthmainnah et al. (2014). The low level of water fertility indicates that the input of organic matter into the waters is low so that the area still has the potential for aquaculture activities (FNC). Meanwhile, according to Samuel et al. (2010) who found 19 species of phytoplankton, mesotrophic waters are categorized as waters with moderate to high fertility.

In addition, one of the indicators to estimate the fertility status of waters is the composition of phytoplankton. This method uses the saprobicity value approach (Hidayat, 2018; Nuriasih & Anggoro, 2018; Suwandana et al. 2018; Hidayat et al., 2019; Siregar et al., 2023). Saprobicity of waters consists of saprobic index and saprobic trophic index. The saprobic index is often used to determine the level of water pollution, while the saprobic tropic index is used to assess water fertility parameters indicated by the composition of organism species, such as phytoplankton.

Based on the aforementioned background, water quality monitoring in Lake Ranau, Lumbok Seminung area, West Lampung, needs to be conducted to determine the impact of FNC activities on water fertility. This study was conducted using saprobicity approach to estimate the water fertility that is suspected to be affected by FNC activities. This study aims to analyze phytoplankton composition and saprobic index based on phytoplankton composition as an indicator of water fertility.

2. Methods

This study was conducted in Lake Ranau, Lumbok Seminung Village, West Lampung Regency. The research stations consisted of 10 points. Each station represents water conditions, namely five points were located close to the FNC area, while the other five points were located far from the FNC area. The determination of sampling location points was based on the representation of the water conditions of Lake Ranau (Figure 1).

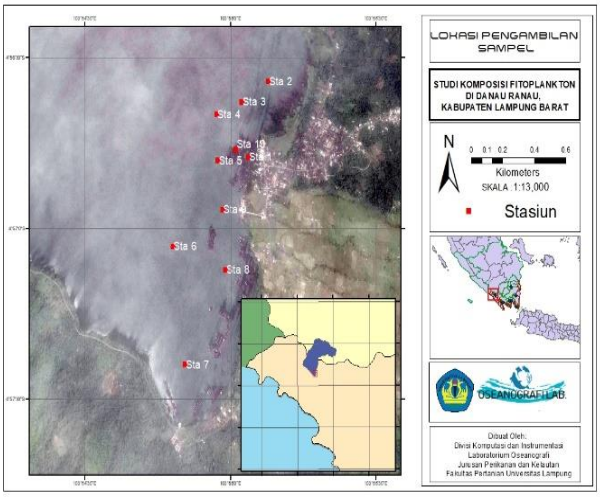


Figure 1. Map of stations at the research location

First, water quality and phytoplankton sampling were conducted. Water quality parameters measured in situ were brightness, depth, current, and temperature. Measurement of nitrate, nitrite, ammonia, and orthophosphate was carried out first by sampling 500 ml of water using Nansen Water Sampler at a depth of 2 meters below the surface. The sample water was then stored in a glass bottle and stored in a coolbox at a constant temperature of 4^{o}C. Cooling was conducted to prevent chemical and biological reactions in the sample water. Nitrate, nitrite, ammonia, and orthophosphate content were then measured and analyzed using spectrophotometric method. Next, phytoplankton samples were taken by filtering 50 l of surface water using a 25 mesh of plankton net with a mesh size of 64 μm. The water filtered was then stored in sample bottles and preserved using lugol solution until the color of water turned orange. Identification of phytoplankton species referred to Bellinger and Sigee (2010). The abundance of phytoplankton samples was counted using the Sedgewick Rafter Counting Cell (SRC) tool with the sweep method, then calculated using the following equation according to the American Public Health Association (2005).

$$N = n \times \frac{Vt}{Vcg} \times \frac{1}{Vd}$$

Description:
N = plankton abundance (cell/l)
n = number of phytoplankton observed in SRCC tool (individual)
Vt = volume of water filtered in a film bottle (50 ml)
Vcg = volume of SRC (1 ml)
Vd = volume of water filtered (50 l)

The calculation of phytoplankton abundance was used to determine the level of water fertility. Shannon-Wienner diversity index was used to determine the level of diversity of species in a community. The uniformity index was used to determine how much similarity in the distribution of a number of individuals of each genus at the community level. The dominance index was calculated using Simpson's index. Diversity index, uniformity index, and dominance index were calculated based on the Odum and Barrett (2009) equation as follows:

$$H' = -\sum \frac{ni}{N} \ln \frac{ni}{N}$$

$$E = \frac{H}{H_{max}}$$

$$C = \sum_{i=1}^{s} \left(\frac{ni}{N}\right)^2$$

Description:
H’ = diversity Index
ni = number of individuals of the i-th species
N = total number of individuals
E = uniformity index
H max = ln S
S = number of species
C = Simpson dominance index

The categories of water conditions were determined based on the criteria of diversity index values according to Odum and Barrett (2009) as follows:

H’ < 1: low species diversity and community stability, low productivity, unstable ecosystems, and high ecological pressure
1 < H’ < 3: moderate species diversity and community stability, moderate productivity, balanced ecosystems, and moderate ecological pressure
H’ > 3: high species diversity and community stability, high productivity, stable and balanced ecosystem, and low ecological pressure

The uniformity and dominance index value ranges from 0–1. The level of uniformity was determined based on the criteria of uniformity index value as follows:

E > 0.6: high uniformity
0.6 ≤ E ≤ 0.4: moderate uniformity
E < 0.4: low uniformity.

The species dominance was determined based on the criteria of dominance index value as follows:

0 ≤ C ≤ 0.5: There is no dominating genus
0.5 < C ≤ 1: There is a dominating genus

The level of water fertility was determined based on phytoplankton abundance refers to Basmi (2000), which divides the level of water fertility into several criteria (Table 1).

Table 1. Water Fertility Criteria Based on Phytoplankton Abundance

Phytoplankton Abundance (cell/l)	**Water Category**	**Description**
< 2,000	Oligotrophic	Low water fertility
2,000–15,000	Mesotrophic	Moderate water fertility
>15,000	Eutrophic	High water fertility

The level of water fertility (X) was also calculated using the saprobity index (Maresi et al., 2015).

X = (C + 3D – B – 3A) / (A + B + C + D)
A : Cyanophyta group, indicates polisaprobic phase
B : Euglenophyta or Flagelata group, indicates α-mesosaprobic phase

C : Chrysophyceae + Diatomae groups, indicate β-mesosaprobic phase
D : Peridinae or Chlorophyta or Conjugatae group, indicates oligosaprobic phase

Water fertility status was determined based on the classification of saprobic index set by Dresscher & Mark (1976) (Table 2).

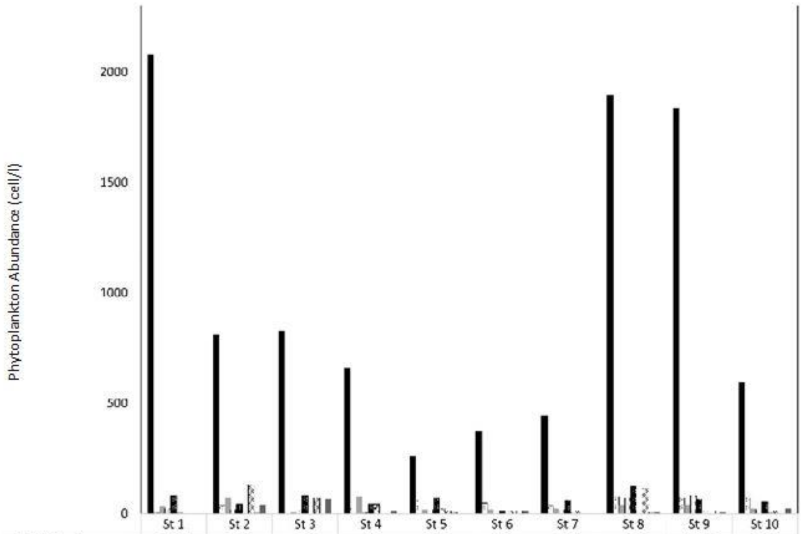
Table 2. Classification of Saprobic Index

Pollution Loads	Pollution Level	Saprobic Phase	Range of Saprobic Index
A lot of organic matters	Very high	Polisaprobic	-3 to -2
		Poli/α-Mesosaprobic	-2 to -1.5
Organic and inorganic matters	Rather high	α-Meso/polisaprobic	-1.5 to -1
		α-mesosaprobic	-1 to -0.5
	Moderate	α/β-mesosaprobic	-0.5 to 0
		β/α-mesosaprobic	0 to +0.5
Little organic and inorganic matters	Mild/low	β-mesosaprobic	+0.5 to +1
		β-Meso/oligosaprobic	+1 to +1.5
	Very low	Oligo/β-mesosaprobic	+1.5 to +2
		Ologosaprobic	+2 to +3

3. Results and Discussion

3.1 Abundance and Community Structure of Phytoplankton

The results of data analysis of samples taken in the waters of Lake Ranau showed that the phytoplankton found were from 9 classes, namely Bacillariophyceae (consists of 16 genus), Chlorophyceae (5 genus), Conjugatophyceae (6 genus), Coscinodiscophyceae (2 genus), Cyanophyceae (7 genus), Mediophyceae (1 genus), Trebouxiophyceae (2 genus), Ulvophyceae (1 genus), and Xanthophyceae (2 genus). Bacillariophyceae class comprises the highest number of genus found. Phytoplankton abundance at each observation station is presented in Figure 2.



	St 1	St 2	St 3	St 4	St 5	St 6	St 7	St 8	St 9	St 10
Bacillariophyceae	2079	810	828	660	258	372	444	1896	1836	594
Chlorophyceae	6	36	24	24	66	48	36	78	72	72
Conjugatophyceae	36	72	6	78	18	18	24	42	42	24
Coscinodiscophyceae	24	18	18	6	18	0	18	72	84	18
Cyanophyceae	84	42	84	42	72	12	60	126	66	54
Mediophyceae	6	0	0	42	24	12	12	0	12	6
Trebouxiophyceae	0	132	72	0	12	12	12	114	0	12
Ulvophyceae	0	6	18	0	6	12	0	6	18	12
Xanthophyceae	0	42	66	12	0	12	0	6	6	24

Figure 2. Phytopankton abundance in the waters of Lake Ranau

The highest phytoplankton abundance obtained from all stations was from species *Nitzhia* sp. (Bacillariophyceae) with a total abundance of 5,868 cells/ml (45.9% of the total phytoplankton individual number). Other abundant species from the Bacillariophyceae class were *Synedra* at 984 cells/ml (8.31%), *Diatoma* at 951 cells/ml (8.03%), and *Tabellaria* at 360 cells/ml (3.04%), and *Chlorella* (Trebouxiophyceae) at 312 cells/ml (2.63%).

The dominant species of diatoms (Bacillariophyceae) found in the waters of Lake Ranau were from the genus *Nitzschia* and *Synedra*. This indicates that diatoms from these groups have high tolerance to variations in water conditions. According to Needham and Needham (1992), phytoplankton groups that dominate freshwater generally consist of diatoms and green algae. Meanwhile, several other studies, such as by Pratiwi et al. (2007, 2013); Astuti and Satria (2009); Kozak (2010); Offem et al. (2011); and Wijaya and Hariyati (2013), found that the class most commonly found in stagnant waters, such as lakes or reservoirs, is Chlorophyceae. A study by Lobo et al. (2010) showed that epilithic diatoms from the genus *Nitzschia* were found most abundantly in rivers located in the southern Brazil region.

The presence of phytoplankton from the Bacillariophyceae class (diatoms), such as *Nitzschia* at all stations, is thought to be because these phytoplankton are indicator species in lightly to moderately polluted waters. *Nitzschia* has a wide range of tolerance towards organic matter pollution and can also act as an indicator in moderately to heavily polluted water conditions (Aprisanti et al., 2013). *Nitzschia* and *Synedra* that appear in the waters according to Gell et al. (2007) and Soeprobowati et al. (2001) is a sign that the waters are in eutrophic conditions and experience organic pollution loads. This is supported by Soeprobowati and Rahadian (2003) that found *Synedra* species in areas around industries. If the abundance of *Nitzschia* and *Synedra* species reach almost 50% of the total abundance of species found, this indicates that the waters observed are moderately to heavily polluted (Soeprobowati et al., 2001). It is further stated that the water is said to be polluted at a moderate level if there is phytoplankton from species *Pinnularia* at the location, while the water is said to be clean if there is phytoplankton from species *Gomphonema* at the location, but this type of phytoplankton was not found in the waters of Lake Ranau.

The analysis results of community structure of phytoplankton in the form of diversity index (H'), uniformity index (E), and dominance index values are presented in Figure 3. The phytoplanton diversity index value obtained ranges from 1.54–3.08, which indicates that the phytoplankton present have low to high diversity. The lowest diversity was obtained at station 8, while the highest diversity was obtained at station 5.

According to Odum and Barrett (2009), low phytoplankton diversity in the waters of Lake Ranau indicates the instability of phytoplankton community in the area. The presence of Bacillariophyceae and Cyanophyceae classes greatly affects the diversity index and uniformity index. The diversity index is considered low when there is a high abundance of species from Bacillariophyeae and Cyanophyceae classes, and the abundance of species from other classes is low. On the other hand, the overall diversity index is considered high when there is a decline in the abundance of species from Bacillariophyeae and Cyanophyceae classes, and the abundance of species from other classes does not change.

The distribution of phytoplankton individuals is expressed by the uniformity index value. The uniformity index value obtained ranges from 0.46–0.90. The uniformity index or equitability (E) describes the distribution of individuals between different species and is obtained from the relationship between diversity (H') and its maximum diversity (Bengen, 2000). The more even the distribution of individuals among various species, the more stable the ecosystem condition to be achieved. The results of the uniformity index analysis show that the phytoplankton community in the waters of Lake Ranau experiences high ecological pressure and low ecosystem stability, and several others are experience low ecological pressure with more stable ecosystem condition (Odum & Barrett, 2009). Existing ecological pressure was encountered in the form of nutrient pollution. The station that experienced a lot of pressure in the form of high ammonia pollution was station 8, while the condition at station 5 was still considered stable.

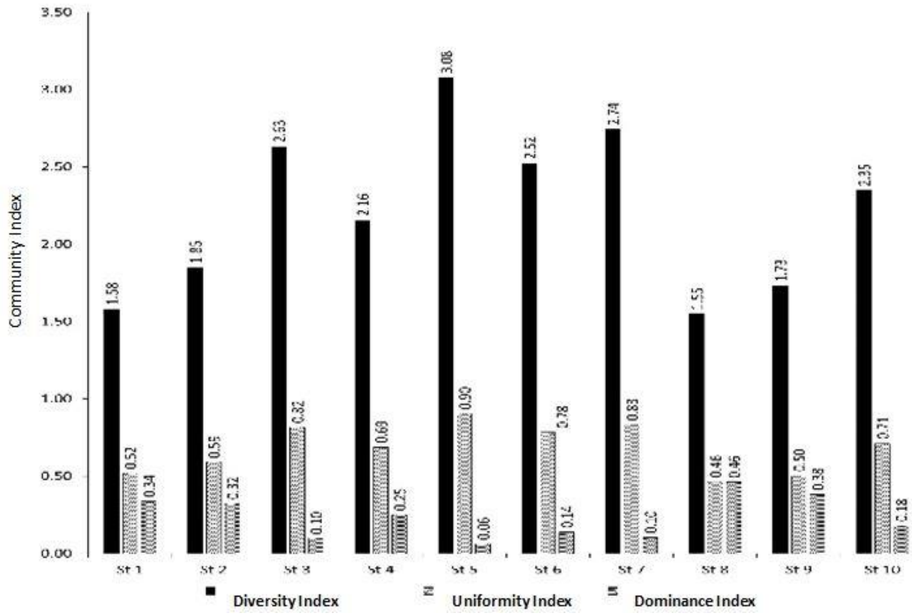


Figure 3. Structure of phytoplankton community in the waters of Lake Ranau

Ecosystem instability has an impact on the distribution of the number of individuals that tend to be unequal one another, which is indicated by the dominance of one species. The dominance of phytoplankton species can be expressed by the dominance index. The results show that the dominance index obtained ranges from 0.06–0.41. The highest dominance index value (0.41) was obtained at station 8, while the lowest dominance index value (0.06) was obtained from station 5. The lowest and highest dominance index values indicate that the dominance still occurs at a low level.

3.2 Water Fertility

Fertility level is determined based on phytoplankton abundance (Basmi, 2000). The water fertility analysis show that the waters of Lake Ranau is in low fertility (oligotrophic) and moderate fertility (mesotrophic) based on the total phytoplankton abundance. Mesotrophic or moderate fertility condition with the highest total phytoplankton abundance (Figure 4) was obtained at station 8, followed by station 1 and station 9. The highest phytoplankton abundance at stations 8 and 9 is greatly thought to be because these two stations were located in areas close to floating net cages (FNC), while station 1 was located close to settlements so that the influence of nutrient supply from household waste and other human activities is quite high. The lowest phytoplankton abundance was obtained at station 5. In fact, the lowest abundance was obtained at stations 5, 6, and 7, which were located quite far from the FNC.

Fish rearing using FNC systems and domestic waste from settlements are problems that cause nutrient enrichment (Lehmusluoto, 2000), while according to Simarmata (2007), excessive fish rearing using FNC will reduce water quality. Early signs of water quality degradation as an early impact of FNC are sedimentation and eutrophication. According to Irianto and Triweko (2011), eutrophication is the enrichment of nutrients and organic matter, indicated by the increase in nitrogen and phosphorus levels in the waters.

The source of nutrients produced from FNC are the remaining wasted feed and fish feces. The worse condition will occur if the waters obtain nutrient input from the surrounding area, such as what often occurs in the lake (Levine & Schindler, 1992). According to Alvarez-Vazquez et al. (2014), fertilizers, detergents, and industrial waste are the main additional sources of nutrients input into the lake. Besides, another source of nutrients in lake waters is the nutrient cycle itself (Schindler et al., 1993).

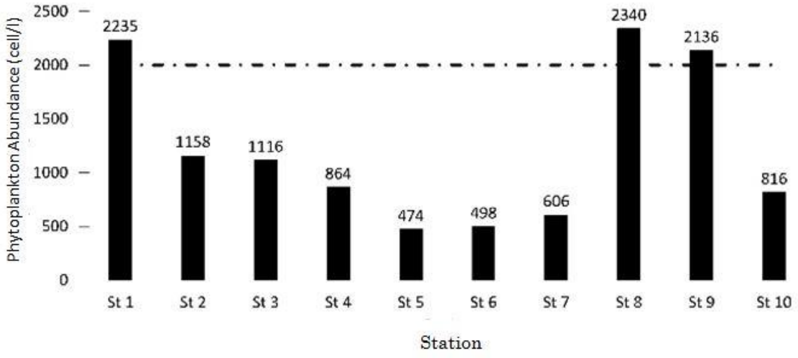


Figure 4. Total phytoplankton abundance in the waters of Lake Ranau. The dashed line indicates the limit of water fertility criteria. Values below the line indicate low water fertility, while values above the line indicate moderate to high water fertility.

The results of water quality measurements indicate the occurrence of eutrophication symptoms due to the increasing amount of organic or inorganic matter in these waters. In stagnant waters such as lakes, nutrients are one of the important things in spurring the primary productivity of waters through the growth of phytoplankton and aquatic plants. The existence of human activities around waters, such as fish rearing in FNC, agriculture, and settlements, will naturally produce waste matters, both in the form of organic and inorganic matters.

The measurement results of dissolved organic matter (Figure 5) show that the total organic matter (dissolved, suspended, and colloidal) concentrations at all research stations are lower than that of the quality standard. The highest total organic matter (TOM) concentration was obtained at station 1 (323.05 mg/l), while the lowest was obtained at station 6 (27.25 mg/l). Organic matter in the waters will undergo mineralization. This is an important process in the water ecosystem because it will break down organic carbon and organic nutrients into inorganic nutrients so as to increase the concentration of nutrients in the water (Bridgham & Ye, 2013). Besides, Effendi (2003) stated that the concentration of TOM will affect the concentration of dissolved oxygen (DO) because it will be used in the process of decomposing organic matter that involves aerobic bacteria. One process that requires dissolved oxygen is the nitrification process, namely the change of ammonia (NH_3) into nitrite (NO_2) and nitrate (NO_3).

Overall, the concentration of total suspended solids (TSS) is still lower than the concentration of organic matter, although the amount of organic matter is influenced by the amount and density of suspended particles. The concentration of TSS (Figure 6) at all stations ranges from 4.0–35.5 mg/l. The highest concentration of TSS was obtained at station 1 and the lowest was obtained at station 9. Based on the Regulation of the Ministry of Environment and Forestry Number P.68 of 2016 on Domestic Wastewater Quality Standards, the TSS concentrations in the waters of Lake Ranau are still lower than that of the quality standard, except at station 1. The high TSS concentration at station 1 is due to the domestic waste entering the waters. TSS concentration generally will be high along with seasonal changes, especially in the transitional season (*pancaroba*) because the intensity of wind blowing increases, which will cause turbulence. TSS concentration will also tend to be high during the rainy season, especially in areas close to land due to increased load of solids transported from the land.

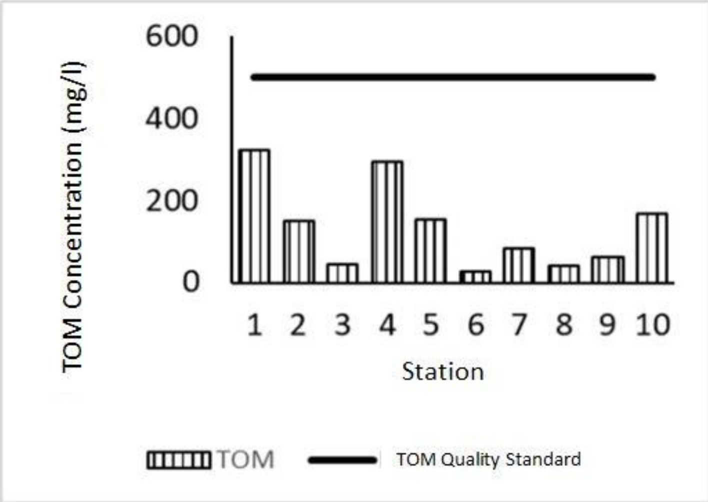


Figure 5. Total organic matter (TOM) concentration in the waters of Lake Ranau

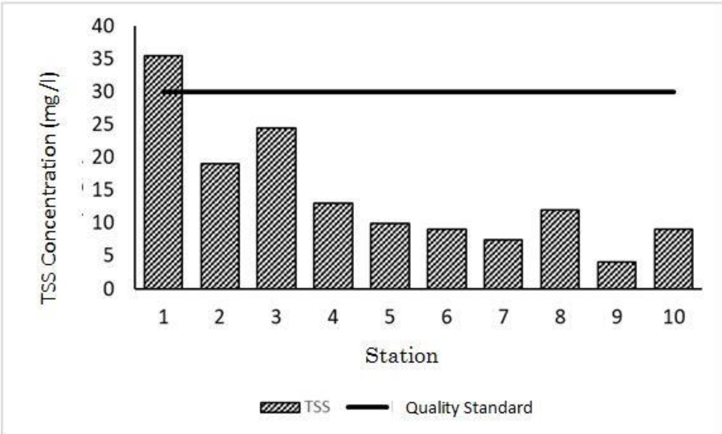


Figure 6. Total suspended solids (TSS) concentration in the waters of Lake Ranau

The average concentration of ammonia in the waters of Lake Ranau (Figure 7) ranges from 0.01–0.11 mg/l, which is generally higher than that of reported by Subagdja et al. (2013), which ranged from 0.014–0.049 mg/l. This is presumably because the amount of nutrient load derived from fish rearing waste has increased along with the increase in the number of floating net cages (FNC) in Lake Ranau. The presence of ammonia in the water is resulted by the decomposition of organic matter, excretion of aquatic organisms, nitrite reduction by bacteria, and fertilization activities (Boyd, 1982). Based on the Regulation of the Government of the Republic of Indonesia Number 82 of 2001 concerning Water Quality Management and Water Pollution Control and the NH_3 quality standard for fisheries, the free ammonia content for sensitive fish is < 0.02 mg/l. Thus, it can be said that the concentration of ammonia in the waters of Lake Ranau is far higher from the quality standard.

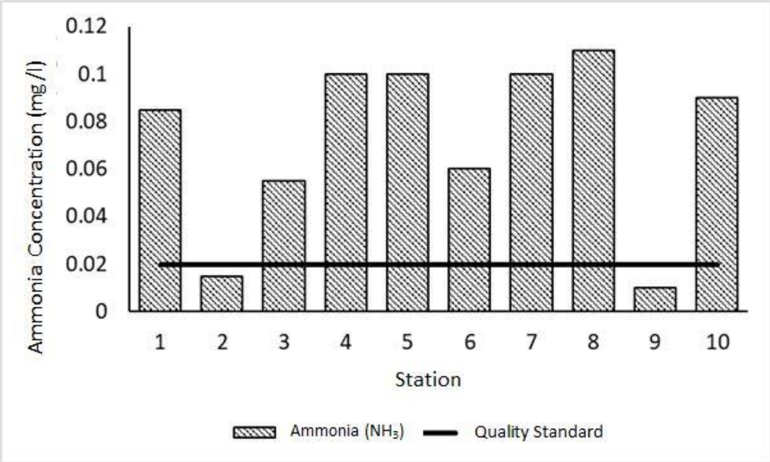


Figure 7. Ammonia concentration in the waters of Lake Ranau

The phosphate concentration value resulted in this study (Figure 8) are still classified as good because it is lower than the quality standard stipulated in the Regulation of the Government of the Republic of Indonesia Number 82 of 2001 concerning Water Quality Management and Water Pollution Control. This value obtained is also lower compared to that of reported by Subagdja et al. (2013). In general, the phosphate concentrations value obtained at all stations are lower than that of the quality standard, except at station 3 (0.22 mg/l), while the lowest concentration was obtained at station 5 (0.0215 mg/l). Cyanophyceae are commonly found in water conditions with high total phosphate concentration (Sulastri, 2011). The results of other studies also mentioned that Cyanophyceae class is a phytoplankton that is strongly influenced by the concentration of orthophosphate so that this group is very abundant at high orthophosphate concentration (Lu et al., 2011; Jiang et al., 2014).

An increase in total phosphate concentration is an indicator that the waters of Lake Ranau has experienced eutrophication (Walker et al., 2007). Furthermore, Likens et al. (1977), Cheng and Li (2006), Richardson et al. (2007) defined the eutrophied waters as the waters with the total phosphate concentration ranging from 10–300 µg/l. In addition, Yang et al. (2008) stated that eutrophication or red tide will occur when nitrogen concentration reaches 300 µg/l and phosphate concentration reaches 20 µg/l. Richardson et al. (2007) also stated that the total phosphate concentration exceeding 15 µg/l will cause ecological imbalance in algae, macrophytes, and macroinvertebrates in the waters.

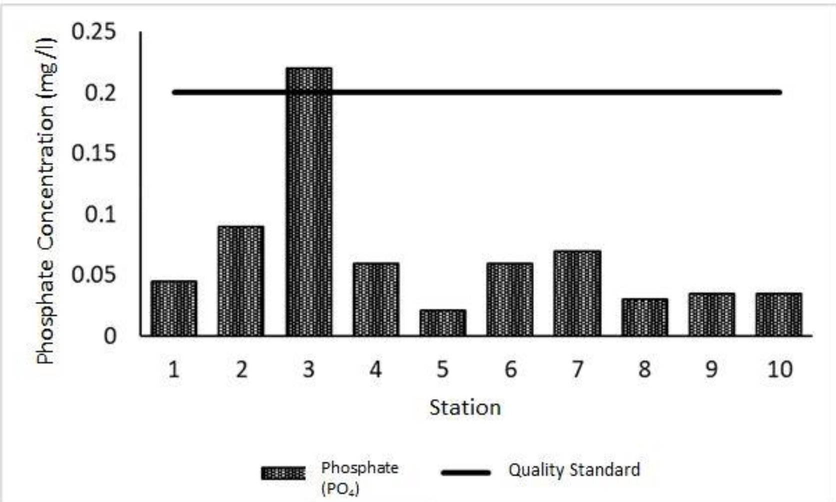


Figure 8. Phosphate concentration in the waters of Lake Ranau

N and P are the most potential nutrients in limiting phytoplankton growth. Phytoplankton growth and proliferation is closely related to the availability of N and P nutrients in the water (Zhang et al., 2021). In addition to the concentration of N and P, the N:P ratio also affects the presence of phytoplankton in the water. In stagnant waters such as lakes, P generally acts as the limiting factor (Schindler, 1977), while N only sometimes act as the limiting factor. Limiting nutrients are the ones that will inhibit phytoplankton growth if the availability of the nutrient is limited. Nutrients that can be said to be the limiting factors in phytoplankton growth can vary both temporally and spatially, depending on the input of N and P into the water.

Agricultural land is one of the sources of nutrients that can enter the waters. One of the agricultural activities, such as fertilization, will often contribute to increase the nitrogen concentration in the waters, thus can cause eutrophication in the waters. The use of fertilizers in agricultural activities around the lake can increase the concentration of nitrogen (in the form of ammonia and nitrate) in the waters (Kattner et al., 2000). Residual fertilizers used in agricultural activities can enter the waters through surface water runoff and rainfall. Therefore, the larger the area of agricultural land, the greater the supply of nutrients entering the water body.

In addition to using phytoplankton abundance as an indicator, the level of water fertility can also be determined based on the diversity of phytoplankton species. Determination of water fertility based on the diversity of saprobic group species results in saprobic index value. The calculation results of saprobic index values are presented in Table 3. Saprobicity value can also be used to determine the level of pollution of a water body. The level of pollution is usually measured based on the content of pollutants in the form of organic or inorganic matters. Waters polluted with high amount of nutrients will cause an explosion of phytoplankton populations that will reduce the level of water brightness (Caddy, 2000 in Suryanti, 2008). Saprobity value is strongly influenced by phytoplankton constituents. Therefore, phytoplankton is often used as an indicator of pollution that occurs in a water body, such as river, because the river condition can be known through the type of phytoplankton found. Besides, the physical and chemical properties of the waters also greatly influence the presence of saprobic phytoplankton species.

Table 3. Saprobic Index Values and Water Fertility Status in Lake Ranau

Station	Saprobic Index	Saprobic Phase	Water Fertility Level	Water Pollution Level
St. 1	0.47	β/α -mesosaprobic	moderate	moderate
St. 2	1.09	β-meso/oligosaprobic	less fertile	low
St. 3	0.75	β-mesosaprobic	less fertile	low
St. 4	1.19	β-meso/oligosaprobic	less fertile	low
St. 5	0.71	β-mesosaprobic	less fertile	low
St. 6	1.26	β-meso/oligosaprobic	less fertile	low
St. 7	1.00	β-meso/oligosaprobic	less fertile	low
St. 8	1.15	β-meso/oligosaprobic	less fertile	low
St. 9	1.14	β-meso/oligosaprobic	less fertile	low
St. 10	1.15	β-meso/oligosaprobic	less fertile	low

The dominance of phytoplankton group from the Bacillariophyceae class is due to the influence of eutrophic water conditions with phosphate concentrations that tend to be high, namely ranging from 0.0215–0.22 mg/l (Figure 8). Bacillariophyceae is a cosmopolite phytoplankton group that has high tolerance and adaptability towards various environmental conditions. Bacillariophyceae also has the ability to store phosphorus and fix nitrogen from the atmosphere (Rakocevic, 2012). Meanwhile, Edwards et al. (2012) stated that Cyanophyceae utilize phosphate better than other phytoplankton classes.

The saprobic index of the plankton community in the waters of Lake Ranau ranges from 0.47–1.26 (Table 3), indicating that the level of pollution that occurred at the research location was relatively mild/low with little pollution caused by the load of organic and inorganic matters. This means the status of the waters of Lake Ranau is in the β-meso/oligosaprobic to β/α-mesosaprobic phase. This result is still in accordance with previous study (Subagdja et al., 2013), which stated that the waters of Lake Ranau around Lumbok area based on the calculation of Tropic State Index (TSI) were in mild eutrophication status.

The oligo/β-mesosaprobic phase indicates that the types of phytoplankton found are from the Bacillariophyta and Chlorophya divisions. This is in accordance with the data obtained, that the types of phytoplankton found at all research stations are dominated by four species from the Bacillariophya division, namely *Aulacoseira granulata*, *Synedra ulna*, *Melosira varians*, and *Surirella* sp. The discovery of these four species at all research stations indicates that these observed areas have been polluted with organic matters.

4. Conclusion

The highest nutrient input load in the waters around Lake Ranau, West Lampung has been produced through floating net cages (FNC), which caused the water fertility status at mild eutrophic condition, with *Nitzhia* sp., *Synedra*, *Diatoma*, and *Tabellaria* (all are from the Bacillariophyceae class) dominated the phytoplankton community structure. The high nutrient input load in the waters of Lake Ranau is thought to affect the phytoplankton community structure. The saprobic index of the plankton community in the waters of Lake Ranau ranges from 0.47–1.26, thereby it is categorized as the β-meso/oligosaprobic to β/α-mesosaprobic phase, meaning that the level of pollution at the research location was relatively mild/low with little pollution caused by the load of organic and inorganic matters.

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