Journal of Coastal and Ocean Sciences *e-issn: 2746-4512*
Volume 5 No. 2, May 2024: 94-100 *p-issn: 2745-4355*

Abundance and Diversity of Phytoplankton in Mangrove Forest Waters of Aek Horsik Village, Central Tapanuli

Lenni Wahyuni Batubara[1*], Henry Sinaga[1], Desi Indriani Dameria Hutagalung[1]
[1]Department of Aquaculture, Sekolah Tinggi Perikanan Sibolga, Sibolga 22357 Indonesia
Corresponding Author: lenniwahyuni@stpsibolga.ac.id

Received: 4 February 2024; Accepted: 5 April 2024

ABSTRACT

Phytoplankton are organisms that live floating in water. Its ability to move is limited, so the organism is always carried away. The waters of mangrove forests in Tapanuli Tengah Regency are directly adjacent to the shoreline, where phytoplankton always follow the current. At high tide, phytoplankton are carried by currents to mangrove forests; at low tide, phytoplankton can be carried by currents to free ocean waters. This study aims to determine the type of phytoplankton, phytoplankton abundance, and the level of phytoplankton diversity in the Mangrove Forest Waters of Aek Horsik Village, Tapanuli Tengah Regency. This research will be conducted from May to June 2023. Phytoplankton samples were taken using the purposive sampling method, and the research station was divided into 3. Station 1 is upstream of the mangrove forest, station 2 is in the middle of the mangrove forest, and station 3 is downstream. The results of this study showed that phytoplankton found in the waters of the Mangrove Forest, Aek Horsik Village, Tapanuli Tengah Regency consisted of 5 classes totaling 15 species, namely: Class Cyanophyceae (*Synedra* sp), Class Euglenophyceae (*Euglena viridis* sp, *E.protista*, and *Euglena* sp), Class Chlorophyceae (*Ankistrodesmus* sp, *Scenedesmus* sp, *Tetraedron caudatum*, *Closterium acutum*), Class Baciliarophyceae (*Navicula* sp, *Nitzchia* sp, *Tabellaria* sp, *Nitzchia sigma*), and Class Zygnematophyceae (*Cosmarium* sp, *Staurastrum* sp, *S. curvacum*). The highest phytoplankton abundance was 6100 Ind/L. Phytoplankton diversity is in the medium category, with the highest value being 2.671.

Keywords: Phytoplankton, Forest Mangrove, Waters

1. INTRODUCTION

Mangrove forest is one form of estuary ecosystem that has many functions, one of which is as a nursery ground (nursery area for tiny organisms before they become adults), spawning ground (spawning area for aquatic organisms to carry out part of their reproductive cycle), or feeding ground (area to find food for an organism) (Hamzah et al., 2012). Mangroves are essential in maintaining the balance of biological interactions in a water body (Aini et al., 2018).

Tapanuli Tengah Regency has a land area of 2,194.98 km^2. The total area of Tapanuli Tengah Regency is ±6,194.98 km^2. The geographical location of Tapanuli Tengah Regency is 0-1,266 mbpl, at 1º11'00"- 2º22'00" LU and 98º07'-98º12' BT. Tapanuli Tengah Regency is one of the areas that has mangroves. The area of mangrove forests in Tapanuli Tengah Regency is 6,931 Ha, but the area in the regional water area in Tapanuli Tengah Regency is ±1,011 Ha with canopy cover conditions around 75%, categorized in good condition (Unedo et al. in Batubara et al., 2023).

Mangroves are vital to the people of Tapanuli Tengah Regency, as they provide a natural ecosystem for fish and animals with economic value. Many people's livelihoods depend on mangrove sustainability. Mangroves are a complex and unique ecosystem with a large carrying capacity for the surrounding environment. Mangrove forests are an ideal place for plankton and larvae of marine life to exist and begin life due to adequate space and food availability.

Mangrove ecosystems play an essential role in the sustainability of coastal ecosystems. Community activities influence nutrient availability. The concentration of nutrients affects the abundance of biota, including phytoplankton. Phytoplankton is a bioindicator of pollution and damage to aquatic ecosystems (Hutami et al., 2017).

Phytoplankton also can provide

dissolved oxygen for other biota from the photosynthesis process with the help of sunlight. Phytoplankton can produce organic matter through photosynthesis (Burhanuddin, 2018).

This study aims to determine the type of phytoplankton, phytoplankton abundance, and the level of phytoplankton diversity in the Mangrove Forest Waters of Aek Horsik Village, Central Tapanuli. Phytoplankton diversity and abundance can indicate the quality of the waters, whereas phytoplankton diversity is a measure of the scouring in the waters. Besides that, phytoplankton abundance can illustrate the density of phytoplankton in an area (Balqis et al., 2021).

2. RESEARCH METHOD

Time and Place

This research was conducted from May to June 2023 in the mangrove forest waters of Aek Horsik Village, located in Tapanuli Tengah Regency. Identification of phytoplankton samples was carried out at the Sibolga Fisheries College Laboratory.

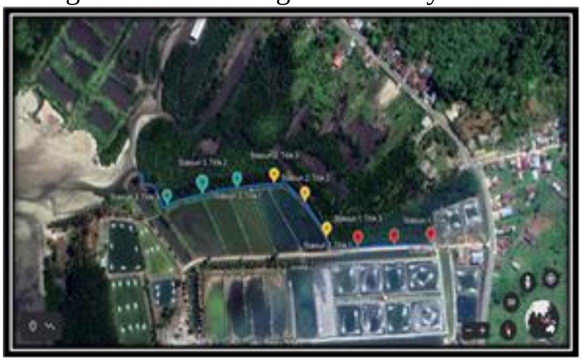

Figure 1. The Research Station

Method

Determination of sampling points and time using purposive sampling method (placement of sample points with survey techniques). Sampling was carried out at three stations, each divided into 3 points as replicates.

Procedures

Research Site Survey

A survey of the research site was carried out to see the field conditions at the time of the study, followed by the division of stations using GPS. Each station has 3 points, where each point in the station is a repetition of taking samples. Determination of sampling points using purposive sampling method (placement of sample points with survey techniques).

Phytoplankton Sampling

Sampling was carried out at three stations determined by the purposive sampling method, where each station was divided into 3 points. Water sampling was carried out using a 20L bucket and filtered using a 30 mesh size 60 mm plankton net five times, and then the filtered sample water was put into a 250 mL almond bottle. After that, 1 mL of lugol solution was dripped to preserve the phytoplankton. Furthermore, the sample bottle is put into black plastic so that the phytoplankton sample is not exposed to light. After that, the sample bottle is put into a styrofoam containing ice cubes so the sample is not damaged during the trip.

Phytoplankton Identification

Phytoplankton were identified at the Sibolga Fisheries College Laboratory using a Binocular Head microscope with 10x magnification and equipped with a phytoplankton identification guidebook.

Water Quality Measurement

The physical and chemical parameters observed were temperature, pH, salinity, brightness, and dissolved oxygen (DO). Measurements were made in situ in the field.

Parameters Observed

Phytoplankton Abundance

The use of the formula for calculating phytoplankton abundance, according to Wisha et al. (2016), is to use the APHA (1989) method formula, namely:

$$K = \frac{\text{N x C}}{\text{V0} - \text{V1}}$$

Description:

K = phytoplankton abundance

N = number of individuals (individuals)

C = the volume of water in the sample bottle (250 mL)

V_0 = volume of filtered water (l00000 mL)

V_1 = volume of a dropper pipette (0.05 mL)

Diversity Index

The diversity index describes the state of phytoplankton mathematically to facilitate the observation of population diversity in an individual. The diversity index can be calculated using the Shannon-Wiener formula according to (Riyantini et al., 2020), namely:

$$H' = \sum_{i-1}^{s} Pi \ln Pi$$

Description:
H' = Species diversity index
s = number of species
Pi = Relative abundance (ni/N)
Ln = Natural Logarithm
ni = number of individuals of the i-th species
N = Total number of individuals

The criteria according to Prawiradilaga et al. in Afif et al. (2014), H' value criteria H'>3= high diversity; H'<3=medium diversity; H'<1 low diversity.

Dominance Index

The dominance index can be calculated using Odum's Simpson formula (1994):

$$C = \sum \left(\frac{ni}{N}\right)^2$$

Description:
C = Species dominance index
pi = Number of individuals of the Ith species to the total number.

Criteria according to Odum in Afif et al. (2014): 0 < C < 0.5 = No dominance; 0.5 < C < 1 = dominance exists

Data Analysis

The data obtained is analyzed descriptively with a quantitative approach that aims to describe the data obtained during the research and then explained descriptively scientifically based on existing theories, combining the theory with the data obtained during the research.

3. RESULT AND DISCUSSION

Phytoplankton Diversity and Abundance

From the results of research conducted in Mangrove Forest Waters, Aek Horsik Village, Tapanuli found phytoplankton with five classes totaling 15 species, namely Cyanophyceae (*Synedra sp*), Euglenophyceae (*Euglena Viridis sp*, *Euglena Protista*, *Euglena sp*), Chlorophyceae (*Ankistrodesmus sp*, *Scenedesmus sp*, *Tetraedron Caudatum*, *Closterium acutum*), Baciliarophyceae (*Navicula sp*, *Nitzchia sp*, *Tabellaria sp*, *Nitzchia Sigma*) and Zygnematophyceae (*Cosmarium sp*, *Staurastrum sp*, *Staurastrum curvacum*). Overall, the *Bacillariophyceae* class has the highest number. This follows the statement (Aini et al., 2018) that the *Bacillariophyceae* class is the most accessible algae class to find in various types of aquatic habitats, Followed by a statement (Lathifah et al., 2017) that the abundance of the *Bacillariophyceae* class because it can adapt to changes in the aquatic environment so that the class is found more with an average number of 1,667 ind/L at high tide, and at low tide with an average number of 1,083 ind/L.

The least found class comes from the *Cyanophyceae* class, with an average number of 0.217 ind/L at high and low tide with an average number of 0.100 ind/L. This is because *Cyanophyceae* can only live in places that have an acidic pH. *Cyanophyceae* are easily found in various environments because they can live in high-salinity seas, lakes, freshwater rivers, and extreme environmental conditions such as high acidity (Masithah, 2020). Meanwhile, the pH obtained during the study ranged from 7.2-7.9 ppt. At the same time, salinity ranges from 4-25 ppt. Phytoplankton diversity and abundance can be seen in Table 1.

The highest phytoplankton abundance was found at station 1 (tide) at 6100 Ind/L, and the lowest was found at station 3 (low tide) at 1950 Ind/L. The high abundance of phytoplankton at station 1 (tide) is thought to be due to the presence of waste discharges from vaname shrimp farming activities that directly enter station 1 as a source of nutrients and water conditions that are more exposed to direct sunlight, causing the process of photosynthesis. Widiana supports this opinion (Aini et al., 2018). High phytoplankton abundance is due to a reasonably open location and clear water, so there is enough sunlight. The low phytoplankton at Station 3 is caused by environmental factors less supportive of phytoplankton growth. Station 3 is an area with sandy substrates and little exposure to sunlight because the waters are quite shady and covered by mangrove branches, thus inhibiting phytoplankton from carrying out the photosynthesis process. Burhanuddin (2018) states that the growth rate of phytoplankton is highly dependent on the availability of light in the waters. The maximum growth rate of phytoplankton will decrease if the waters are in a low-light availability condition.

Table 1. Phytoplankton Diversity and Abundance

Station	Phytoplankton Type		Phytoplankton Abundance	
	Class	Species	P	S
1	Cyanophyceae	*Synedra* sp	0,300	0,100
	Euglenopyceae	*Euglena viridis* *E. Protista* *Euglena* sp	1,200	0,650
	Chlorophyceae	*Ankistrodesmus* sp *Scenedesmus* sp *Tetraedron caudatum* *Closterium acutum*	1,450	0,700
	Baciliarophyceae	*Navicula* sp *Nitzchia* sp *Tabellaria sp* *N. sigma*	2,100	1,000
	Zygnematophyceae	*Cosmarium* sp *Staurastrum* sp *S. curvacum*	1,050	0,450
	Total		6,100	2,900
2	Cyanophyceae	*Synedra sp*	0,200	0,150
	Euglenopyceae	*E.viridis* *E.protista* *Euglena* sp	1,050	0,800
	Chlorophyceae	*Ankistrodesmus* sp *Scenedesmus* sp *T. caudatum* *C.acutum*	1,200	0,950
	Baciliarophyceae	*Navicula* sp *Nitzchia* sp *Tabellaria sp* *N.sigma*	1,700	1,450
	Zygnematophyceae	*Cosmarium* sp *Staurastrum* sp *S.curvacum*	0,800	0,550
	Total		4,950	3,900
3	Cyanophyceae	*Synedra sp*	0,150	0,050
	Euglenopyceae	*E.viridis* *E.protista* *Euglena* sp	0,750	0,450
	Chlorophyceae	*Ankistrodesmus* sp *Scenedesmus* sp *T. caudatum* *C.acutum*	0,800	0,400
	Baciliarophyceae	*Navicula* sp *Nitzchia* sp *Tabellaria sp* *N.sigma*	1,200	0,800
	Zygnematophyceae	*Cosmarium* sp *Staurastrum* sp *S.curvacum*	0,500	0,250
	Total		3,400	1,950

Phytoplankton Diversity and Dominance

The diversity index (H') is a description of the state of the population of organisms, the number of individuals of each species in a community, and the dominance index (Index of dominance) is a parameter that states the level of centralized dominance (mastery) of species in a community.

The phytoplankton diversity index at each station at high tide does not experience a significant difference. Each station's average diversity index (tide) spread across several points of the study location was obtained at 2.648. While at low tide, the average phytoplankton diversity index is 2.589. This value is included in the medium category (Figure 2).

The dominance index of phytoplankton at each station at high tide does not experience a significant difference. The average dominance index when (tide) from each station spread across several points of the research location was obtained at 0.075. While at low tide, the average phytoplankton dominance index is 0.083. This value is included in the low category.

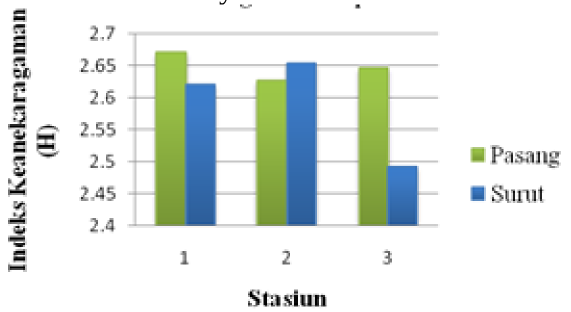

Figure 2. Phytoplankton Diversity Index

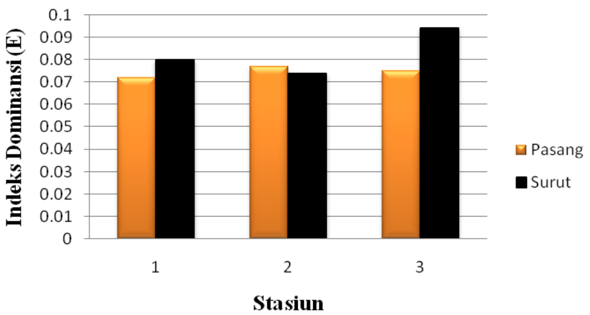

Figure 3. Phytoplankton Dominance Index

Based on the results of Figure 3, it can be seen that the highest phytoplankton diversity index is at station 1 (tide) of 2.671. This value is included in the medium diversity category. Moreover, the lowest was at Station 3 (low tide) at 2.492. This value is included in the medium diversity category. This is because station 1 found more phytoplankton abundance than the other stations.

Wiyarsih et al. (2019) Stated that if the diversity index of a community is high, the ecosystem in the area has a balanced environment. If the diversity value is low, it shows that the aquatic ecosystem is unstable and does not support the life of biota. This is followed by a statement (Odum in Dimenta et al., 2018) that the diversity index's high and low values can indicate phytoplankton's ability to adapt. A low H' value indicates a weak tolerance of phytoplankton to unfavorable environmental factors, so only particular genus are abundant. Conversely, high diversity values can be due to the ability of plankton species to adapt to the environment so that productivity is high.

The dominance index is used to see the level of dominance of certain biota groups in a habitat and the good or bad conditions of the waters. The resulting number on the dominance value varies from 0.22,4-0.248, with an average of 0.075-0.083. This means that in the research location, no phytoplankton species dominate because the range of values is close to 0. According to (Aprianti et al. in Balqis et al., 2021), if the dominance index (C) is close to the value 1, then one species dominates other species. The value of the phytoplankton dominance index ranges from 0-1. If the dominance index is close to 0, it means that in the community structure of the observed biota, no species conspicuously dominates other species.

However, the highest phytoplankton dominance index was at station 3 (low tide) of 0.094. Furthermore, the lowest was at Station 1 (tide) at 0.072. This is thought to be because station 3 is in direct contact with free waters, so phytoplankton in the sea are pushed in during the tide. At station 1 (tide), phytoplankton movement is very passive due to the many mangrove roots that hinder its spread. This follows the opinion of Ayuingtyas et al. (2019), who state that mangrove waters have relatively calm wave movements because vegetation roots block them. Hence, as a passive biota, the phytoplankton dominance index is lower than sea waters.

The dominance index obtained in this study is lower when compared to the dominance index obtained by (Rahmatullah et al., 2016) with the results of the overall dominance index in the Kuala Rigaih estuary, Setia Bakti District, Aceh Jaya Regency, namely with a value of 0.18. Based on the criteria in the Simpson dominance index formula, the dominance of the Kuala Rigaih estuary is categorized as a low dominance index. This was followed by research by Hutami et al. (2017), which obtained the phytoplankton dominance index value (C) at high tide ranges from 0.17-0.53. Meanwhile, the dominance index value at low tide ranges from 0.18-0.26. Furthermore, Wiyarsih et al. (2019) obtained a dominance index value with varying values at each location. The dominance index value in December 2016 ranged from 0.18-0.39, and January 2017 ranged from 0.25-0.44.

Water Quality

From the study results, the temperature was obtained with a value of 29-33^0 C, the temperature limit which is classified as optimal ranges from 29-33^0 C. There are differences in temperature from each station, which is influenced by differences in sunlight intensity and the occurrence of tides and ebbs. The optimum temperature for aquatic phytoplankton growth is 20-30°C (Yuliana et al. in Hutami et al., 2017). According to Effendi in Balqis et al. (2021), 25-30^0 C is the best temperature for phytoplankton life.

The degree of acidity (pH) in a body of water is an important parameter in monitoring the water's stability. From the results of pH measurements taken during the study, the pH value was 7.3 ppt in the morning (tide), 7.8 ppt in the afternoon (low tide), and 7.6 ppt in the afternoon (high tide). According to Widiana in Gurning et al. (2020), the optimum pH for phytoplankton growth ranges from 6.5 to 8.0. Based on the above opinion, it can be said that the pH in the waters of the Mangrove Forest of Aek Horsik Village, Central Tapanuli Regency, is still classified as optimum for phytoplankton growth because it is included in the neutral-alkaline category.

Salinity is the concentration of all dissolved ions in water and is expressed in mg per liter or parts per million or mile. The salinity obtained during the study was 23 ppm in the morning (high tide), 13 ppm in the afternoon (low tide), and 16 ppm in the afternoon (high tide). Hutami et al. (2017) argue that phytoplankton can develop well at 15-32 ppm salinity. Salinity dramatically affects the distribution of phytoplankton. Balqis et al. (2021) stated that the flow of sea and land water, rainfall, evaporation, and tides influences the salinity of a body of water. The amount of salinity that occurs determines the nature of aquatic organisms, especially plankton, which are sensitive to change.

Light has the most significant indirect influence on the development and growth of phytoplankton, namely as a source of light energy to carry out the photosynthesis process. The brightness value can affect the abundance of phytoplankton because phytoplankton need light for photosynthesis. The brightness obtained during the study was 0.87m in the morning (high tide), 0.40m in the afternoon (low tide), and 0.79 m in the afternoon (high tide). Suardiani et al. (2018) stated that the optimal water brightness for aquatic organisms ranges from> 45 cm.

The DO content in a body of water is strongly related to the pollution level, the type of waste, and the amount of organic matter. The DO obtained during the study is with a value range of 5ml/L in the morning (tide), 5.6 in the afternoon (ebb), and 5.6 in the afternoon (tide). The DO obtained during the study was classified as good. This follows the quality standard value (Kep.51/MENKLH/2004) of dissolved oxygen at >5 ppm.

4. CONCLUSION

Phytoplankton found in the waters of Mangrove Forest, Aek Horsik Village, Central Tapanuli consisted of 5 classes totaling 15 species, namely: Cyanophyceae (*Synedra sp*), Euglenophyceae (*Euglena Viridis sp*, *Euglena Protista*, *Euglena sp*), Chlorophyceae (*Ankistrodesmus sp*, *Scenedesmus sp*, *Tetraedron Caudatum*, *Closterium acutum*), Baciliarophyceae (*Navicula sp*, *Nitzchia sp*, *Tabellaria sp*, *Nitzchia Sigma*) and Zygnematophyceae (*Cosmarium sp*, *Staurastrum sp*, *Staurastrum curvacum*). The highest phytoplankton abundance was 6100 Ind/l, and the lowest was 1950 Ind/l. Phytoplankton diversity is in the medium category, with the highest value of 2,671. Furthermore, the lowest was 2.492.

REFERENCES

Afif, A., Widianingsih, W., & Hartati R. (2014). Komposisi dan Kelimpahan Plankton di Perairan Pulau Gusung Kepulauan Selayar Sulawesi Selatan. *Journal of Marine Research,* 3(3): 324-331

Aini, A.Q.Y., Idrus, A.A., & Japa, L. (2018). Komunitas Plankton pada Perairan Habitat Mangrove di Gili Sulat Lombok Timur. *Prosiding Seminar Nasional Pendidikan Biologi*.

Ayuingtyas, C.W., Yona, D., Syarifah, H.J., & Irnawati, F. (2019). Kelimpahan Mikro Plastik di Bayuurip, Gresik, Jawa Timur. *Journal of Fisheries and Marine Research,* 3(1): 41-45.

Balqis, N., El Rahimi, S.A., & Damora, A. (2021). Keanekaragaman dan Kelimpahan Fitoplankton di Perairan Ekosistem Mangrove Desa Rantau Panjang, Kecamatan Rantau Selamat, Kabupaten Aceh Timur. *Jurnal Kelautan dan Perikanan Indonesia*, 1(1): 35-43.

Batubara, L.W., Sihombing, N.S., & Daeli, J.S. (2023). Kelimpahan dan Pola Sebaran Kerang Lokan (*Geloina erosa*) Diperairan Hutan Mangrove Kelurahan Aek Horsik Kabupaten Tapanuli Tengah. *TAPIAN NAULI: Jurnal Penelitian Terapan Perikanan dan Kelautan*, 5(2): 40-45.

Burhanuddin, A.I. (2018). *Pengantar Ilmu Kelautan dan Perikanan*. Deepublish.

Dimenta, R.H., Khairul, K., & Machrizal, R. (2018). Studi Keanekaragaman Plankton Sebagai Pakan Alami Udang pada Perairan Ekosistem Mangrove Belawan, Sumatera Utara. *Jurnal Pembelajaran dan Biologi Nukleus,* 4(2): 18-23.

Gurning, L.F.P., Nuraini, R.A.T., & Suryono, S. (2020). Kelimpahan Fitoplankton Penyebab Harmful Algal Bloom di Perairan Desa Bedono, Demak. *Journal of Marine Research,* 9(3): 251-260.

Hamzah, F., Tito, C.K., & Pancawati, Y. (2015). Pengaruh Faktor Lingkungan terhadap Struktur Komunitas Plankton pada Ekosistem Mangrove Muara Angke, Jakarta Utara. *Balai Penelitian dan Observasi Laut,* (2015): 1-14

Hutami, H.G., Muskananfola, R.M., & Sulardiono, B. (2017). Analisis Kualitas Perairan Perairan pada Ekosistem Mangrove berdasarkan Kelimpahan Fitoplankton dan Nitrat Fosfat di Desa Bedono Demak. *Journal of Maquares,* 6(3): 239 – 246.

Kepmen-LH No. 51 Tahun 2004, Tentang Baku Mutu Air Laut.

Lathifah, N., Hidayat, J.W., & Muhammad, F. (2017). Struktur Komunitas Fitoplankton sebagai Dasar Pengelolaan Kualitas Perairan Pantai Mangrove di Tapak Tugurejo Semarang. *Bioma: Berkala Ilmiah Biologi*, 19(2): 164-169.

Masithah, E.D. (2020). Cyanophyta, Antagonisme Pembunuh dan Pionir Kehidupan. *Universitas Airlangga News.*

Rahmatullah, R. (2016). *Keanekaragaman dan Dominansi Plankton di Estuari Kuala Rigaih Kecamatan Setia Bakti Kabupaten Aceh Jaya*. Syiah Kuala University.

Riyantini, I., Ismail, M.R., & Mulyani, Y. (2020). Zooplankton sebagai Bioindikator Kesuburan Perairan di Hutan Mangrove Teluk Ciletuh, Kabupaten Sukabumi. *Akuatika Indonesia,* 5(2): 86-93.

Suardiani, N.K., Arthana, I.W., & Kartika, G.R.A. (2018). Produktivitas Primer Fitoplankton pada Daerah Penangkapan Ikan Di Taman Wisata Alam Danau Buyan, Buleleng, Bali. *Jurnal Current Trends in Aquatic Science*, 1(1): 8-15.

Wisha, U.J, Yusuf, M., & Maslukah, L. (2016). Kelimpahan Fitoplankton dan Konsentrasi TSS sebagai Indikator Penentu Kondisi Perairan Muara Sungai Porong. *Jurnal Kelautan: Indonesian Journal of Marine Science and Technology*, 9(2): 122-129.

Wiyarsih, B., Endrawati, H., & Sedjati, S. (2019). Komposisi dan Kelimpahan Fitoplankton di Laguna Segara Anakan, Cilacap. *Buletin Oseanografi Marina* 8(1): 1-8.