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ANALYSIS OF PHYSICO–CHEMICAL PARAMETERS ON PHYTOPLANKTON ABUNDANCE IN THE WATERS OF LABAKKANG DISTRICT, PANGKEP REGENCY

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ABSTRACT

Pangkep Regency is dominated by pond areas, one of which is located in Labakkang District. These aquaculture activities affect physico-chemical parameters in the waters. This study was aimed to analyze the influence and relationship of physico-chemical parameters on phytoplankton abundance in the waters of Labakkang District, Pangkep Regency. Data were collected using purposive sampling method in several locations, namely waters around river mouths, waters around mangroves, pond discharge waters and waters around docks. The physico-chemical parameters observed include temperature, salinity, nitrate, phosphate, Total Suspended Solid (TSS), carbon dioxide and current velocity. The results showed that the highest phytoplankton abundance was found in the waters around the river mouth with a value of 741 cells/L, while the lowest abundance was found in the pond discharge waters with a value of 154 cells/L. At the station, the highest values were obtained in the temperature parameter of 32,67ºC, nitrate of 0,03 mg/L, phosphate of 0,08 mg/L, TSS of 25,26 mg/L and current speed of 0,25 m/s. The high abundance of phytoplankton is inversely proportional to the salinity level in the water, which is 29‰. The results of the analysis using the one-way ANOVA statistical test showed significant differences in phytoplankton abundance as well as temperature, salinity and TSS parameters between sampling stations. Then multiple regression analysis showed that the most influential parameters on phytoplankton abundance were temperature, nitrate, and TSS with a coefficient of determination of 92,8%. The results of this study can serve as a basis for more effective water management and better environmental monitoring in the context of aquaculture activities in the region.

Keywords: Phytoplankton abundance, Labakkang, Pond, physico-chemical parameters

INTRODUCTION

Plankton generally may be divided into phytoplankton and zooplankton. Based on the syllable, phytoplankton comes from the word *phyto* which means plant. Phytoplankton can be interpreted as organisms that act as primary producers and are autotrophic. Zooplankton comes from the word *zoo* which means animal, zooplankton is an organism that utilizes other organisms such as phytoplankton as a source of energy and is heterotrophic. Apart from phytoplankton and zooplankton, bacterioplankton and virioplankton can also be found in surface waters (Hertika *et al.*, 2021).

Phytoplankton is an autotrophic organism that can carry out photosynthesis to produce its own energy. The results of photosynthesis in the form of oxygen are used by other living organisms and the energy obtained is used in their growth. Phytoplankton is the main source of energy for organisms such as zooplankton which then form a food chain to higher-level consumers. Phytoplankton abundance is influenced by physical and chemical factors of water (Sari *et al.*, 2017).

According to Arinardi (1997) in Juadi *et al*. (2018), there are four dominant phytoplankton classes found in the waters including Bacillariophyceae, Dinophyceae, Chlorophyceae and Cyanophyceae. Bacillariophyceae is the most common class of phytoplankton found in waters. This phytoplankton is characterized by faster growth when nutrients are available (Ferreira *et al*., 2020). Apart from Bacillariophyceae, the phytoplankton class that is also dominant in waters is Dinophyceae. The movement of Dinophyceae, apart from being carried by the current, has a means of movement in the form of flagella with a whip-like shape (Cokrowati *et al.,* 2014).

Green discoloration in waters is caused by the presence of green algae known as Chlorophyta. Its distribution in waters depends on sufficient light intensity to carry out photosynthesis (Ramdan & Nuraeni, 2021). Another dominant class of phytoplankton found in waters is Cyanophyceae. Like the other three phytoplankton classes, Cyanophyceae is also adaptable despite high fluctuations in dissolved oxygen concentration (Herawati *et al*., 2017).

Chemical parameters that support phytoplankton abundance are nutrient content. Nutrients in the water can be in the form of nitrates and phosphates which play an important role for the growth and development of marine biota, namely phytoplankton. Nitrate and phosphate help in the formation of tissue cells and the process of photosynthesis. In addition to playing a role in the growth and development of phytoplankton, nitrate and phosphate are also indicators of water fertility (Paiki & Kalor, 2017).

Other physico-chemical parameters that can affect phytoplankton abundance are temperature, salinity and water clarity. Sabran *et al*. (2016) in their research suggested that these parameters support the survival of plankton in the waters. Physico-chemical parameters have a close relationship to plankton abundance. Samawi *et al*. (2020) added physical parameters that also affect phytoplankton abundance, namely current velocity and TSS (Total Suspended Solid).

Nurfadilah *et al.* (2020) stated that river estuaries contain high nutrients because settlement, pond and industrial activities trigger an increase in nitrates and phosphates. This causes an increase in phytoplankton abundance in the estuary. Excess phytoplankton abundance causes eutrophication which can endanger biota in these waters.

Waters around mangroves also have abundant nutrient levels, especially nitrate and phosphate levels. Mangrove vegetation supports the fertility of waters with abundant nutrients. This is caused by mangrove litter that falls in the water and is decomposed by decomposers, namely bacteria and fungi into the main source of detritus. The decomposition results increase nutrient levels around the waters, especially nitrates and phosphates (Mustofa, 2015).

Pangkep Regency is one of the areas where most of the area is ponds. This region experienced an increase in the area of ponds by 5,749 ha in 11 years. This event was caused by the conversion of paddy fields into ponds because there was an increase in salinity in paddy fields adjacent to the ponds, resulting in low productivity of paddy fields (Mustafa *et al*., 2006).

Pangkep Regency also has several docks that are used by the community as a place to dock ships for crossing and also loading and unloading marine catches. Ship activities cause stirring of sediments at the bottom of the water. The stirring causes nutrients on the seabed to reach the water column, affecting the quality of the surrounding waters (Fauzan *et al*., 2015).

Physical and chemical parameters can affect phytoplankton abundance. Especially in river estuary areas, pond discharges, docks and mangrove areas that provide more nutrients than other marine areas. However, to determine the effect of physico-chemical parameters on phytoplankton abundance in the waters of Labakkang District, Pangkep Regency, research was conducted.

MATERIALS AND METHODS

This research was conducted from November to December 2022 in Labakkang District, Pangkep Regency. Plankton sampling and water quality samples were collected directly in the field. Measurement of chemical physics parameters was carried out in the field and Chemical Oceanography Laboratory, Faculty of Marine Science and Fisheries, Hasanuddin University.

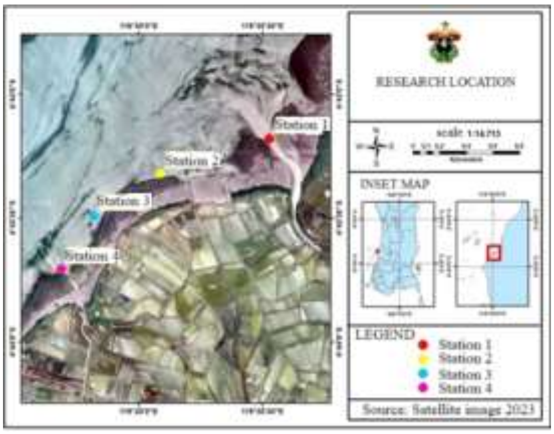

Figure 1. Research Location

The determination of the station was carried out by purposive sampling, namely sampling by determining certain criteria to obtain samples that can represent the population around the sample so that an overall picture of the research site is obtained. This study used four stations based on nutrient contributors in the waters. Station I is located at the mouth of the river, station II is located in the waters around mangroves, station III in the discharge waters of pond activities, and station IV in the waters around the pier.

Water Sampling

Phytoplankton sampling was obtained from filtering water samples at the surface using plankton net No. 25 as much as 100 liters. Plankton extracts that have been collected are transferred into a sample bottle (100 mL) and then given 1% lugol solution. The filtering results were put into a cool box for further analysis in the laboratory.

Each station was repeated three times so that 3 sample bottles were obtained for each station. Sampling was carried out at 10.00–14.00. Water quality sampling is done by taking a 1 L water sample to be analyzed in the laboratory. Measurement of carbon dioxide levels is done by taking a 25 mL water sample. Each station was sampled 3 times repetition.

Parameter Measurement

Parameter measurements taken directly in the field include temperature, carbon dioxide, and current speed and direction. Temperature measurements are made by inserting a thermometer into the water and then reading the temperature scale printed on the thermometer. Determination of carbon dioxide concentration (CO_2) using the titration method. Current speed is measured using a current kite that is released in the waters and measurement of current direction using a compass. Parameter measurements carried out in the Chemical Oceanography laboratory are salinity, TSS, nitrate and phosphate. Salinity measurements using a refractometer by dropping water samples onto the prism glass and then pressing the read button on the tool. TSS (Total Suspended Solid) was analyzed using the Gravimetric method. Determination of nitrate concentration was carried out using the Brucine method. Determination of phosphate concentration was carried out using the Stannous chloride method.

Data Analysis

Plankton observations were made using a microscope in the laboratory. Sedgwick Rafter Counting (SRC) was rinsed using distilled water and then dried. Then the sample water from plankton filtering is dripped on the SRC using a dropper pipette and then closed, in this case there should be no bubbles to facilitate observation under a microscope. After the plankton preparation is ready, it is then placed on the preparation table and then set the right position, light, magnification, and focus to facilitate observation. Plankton were observed in each field of view and the number was recorded. Plankton abundance (N) was measured using the formula (APHA, 2005):

$$N = n \times \frac{V_t}{V_{cg}} \times \frac{1}{V_d}$$

Description:
n = number of phytoplankton cells (cells)
Vt = Volume of filtered plankton sample (mL)
Vcg = Volume of water in SRC (mL)
Vd = Volume of filtered plankton sample (L)

Carbon Dioxide (CO_2) is known using the following formula (Alimby & Triajie, 2021):

$$CO_2 = \left(\frac{V_{titran} \times N_{titran} \times 44/2 \times 1000}{V}\right)$$

Description:
Vtitran = Volume of Na_2CO_3 (mL)
Ntitran = Normality of Na_2CO_3 (N)
V = Volume of water sample (mL)

Current velocity (v) was measured using the formula (Riandi *et al*., 2022):

$$v = \frac{s}{t}$$

Description:
s = current overpass displacement distance (m)
t = time the rope is stretched (s)

The data analysis used was one-way Anova to test differences in chemical physical parameters and phytoplankton abundance at each station. In addition, multiple linear regression analysis was also conducted to determine the relationship of chemical physical parameters to phytoplankton abundance.

RESULTS AND DISCUSSION

Oceanographic parameters in the waters of Labakkang District, Pangkep Regency at each station include temperature, salinity, nitrate, phosphate, Total Suspended Solid (TSS), current speed and free carbon dioxide. The measurement results are presented in the following table.

The average temperature range at the study site is 30-33ºC. The temperature can still be tolerated by phytoplankton in the study site. According to Wardoyo (1983) in Yanasari *et al*. (2017) plankton growth in tropical waters is still normal at temperatures of 21-35ºC. The difference in temperature at each station is influenced by temperature measurements at different times. The highest temperature was at station I (River Estuary area) because it was influenced by the sampling time at 12.30 with high sun intensity and lack of cloud cover. This is in line with the explanation of Tambaru *et al*. (2014) that the abundance of phytoplankton on the surface increases at 12.00 and 15.00 due to the greater amount of sunlight entering the water column.

The results of salinity measurements at the study site ranged from 29-32 ‰. The lowest salinity was at station 1 which is located at the mouth of the river. The input of freshwater into marine waters causes a decrease in salinity at this location. Other stations have a normal salinity range in marine waters, which is in the range of 30-32‰. This is in line with the opinion of Ridho *et al*. (2020) that salinity in estuarine waters tends to be low at low tide due to the influence of freshwater flow.

Table 1. Average measurement results of environmental parameters in the waters of Labakkang District

Parameters	Observation Station				Sample Quantity
	Stasiun 1	Stasiun 2	Stasiun 3	Stasiun 4	
Temperature (ºC)	32,67±0,58	32,33±0,58	30±0,00	30,33±0,58	12
Salinity (‰)	29±0,00	30,33±0,58	31,33±0,58	31,33±0,58	12
Nitrate (mg/L)	0,03±0,00	0,03±0,01	0,01±0,00	0,02±0,01	12
Phosphate (mg/L)	0,08±0,01	0,07±0,01	0,02±0,01	0,04±0,03	12
TSS (mg/L)	25,26±3,76	21,64±1,32	30,07±2,16	35,64±2,97	12
Current Velocity (m/s)	0,25±0,01	0,22±0,12	0,22±0,03	0,15±0,05	12
CO_2 (mg/L)	0±0,00	0±0,00	0,00±0,00	26,10±3,31	12

The highest nitrate concentration is located at station I (estuary area) and station II (mangrove area) with an average of 0,03 mg/L. The river estuary contains high nutrients so that the fertilization process occurs. Nutrients that enter marine waters come from land then flow through rivers and end up in marine waters (Meiriyani *et al*., 2011). The high concentration of nitrate at station II is caused by the waters around the mangrove location. Mangrove litter that falls in the waters will be decomposed by bacteria or fungi into nutrients including nitrates (Mustofa, 2015).

The highest phosphate concentration was found at station I (estuary area) with an average value of 0,09 mg/L and the lowest phosphate concentration was found at station III (pond discharge area) with an average of 0,02 mg/L. This is caused by river flow that carries nutrients from human activities and aquaculture activities in the area. Permatasari *et al*. (2016) explained that phosphate concentrations can increase in river estuaries due to the presence of aquaculture activities along the river flow.

Based on the research results, the highest TSS concentration is at station IV which is located in the dock area with an average of 35,64 mg/L. This can be caused because the dock area is the main traffic for fishing boats to bring in their catch. The ship's passage causes stirring of the substrate in the water so that it becomes cloudy (Anisah, 2017). The lowest TSS concentration was at station II (pond discharge area). This is due to the distance of the sampling location is quite far from human activity so that the lack of input of suspended solids at that location. According to Helfinalis *et al*. (2012), the increase in total suspended solids in waters comes from land and human activities carried by river flow to marine waters.

The average current speed at the study site ranged from 0,15-0,25 m/s. This current is classified as a slow current. According to Darmawan *et al*. (2018), the current is classified into 6 namely very fast current (>1 m/s), fast current (0,5-1 m/s), medium current (0,25-0,5 m/s), slow current (0,1-0,25 m/s) and very slow current (<0,1 m/s). The results of the research conducted obtained current direction at station I leads to the East. While at station II, station III, and station IV leads to the West and Southwest.

Free carbon dioxide is only found at station 4 with an average of 26,10 mg/L while at station I, station II, and station III it cannot be detected. According to Idrus (2018), calm waters cause less exchange of carbon dioxide in the air and water. So that the results of carbon dioxide diffusion react with other elements and then the water on the surface swirls towards the bottom of the water. In addition, undetectable carbon dioxide can also be influenced by aquatic organisms. Ruslaini and Iba (2011) explained that free carbon dioxide in waters is difficult to detect because carbon dioxide is immediately absorbed by plant organisms including phytoplankton for photosynthesis purposes.

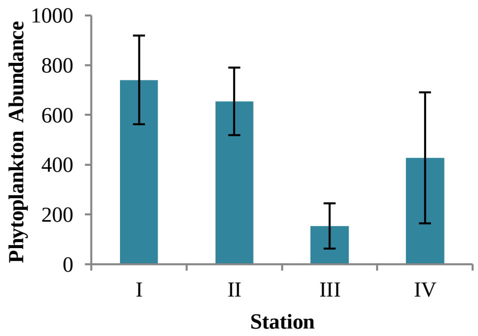

Figure 2. Phytoplankton abundance by station

The highest phytoplankton abundance is located in the estuarine waters, namely station I with an average value of 741 cells/L. This is due to the high nutrients coming from the land. Nurfadilah *et al*. (2020) stated that the mouth of the Pangkep river has a high abundance of phytoplankton. The lowest phytoplankton abundance was found at station III (pond discharge area) with an average value of 154 cells/L. The low abundance of phytoplankton in the area is thought to be due to a lack of nutrients. In accordance with the statement of Mustofa (2015) that the more optimal the nitrate and phosphate content, the phytoplankton abundance will also increase. Observations obtained 2 classes of phytoplankton with the highest abundance in the Bacillariophyceae class and followed by the Dinophyceae class plankton as presented in Figure 3.

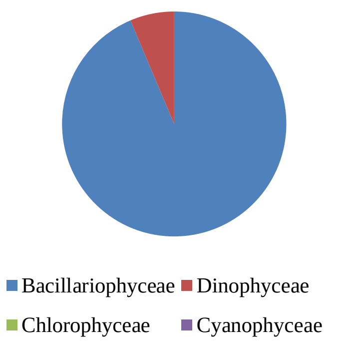

Figure 3. Phytoplankton abundance by class

The largest phytoplankton class is inhabited by Bacillariophyceae of the genus *Chaetoceros*. This is in line with the opinion of Dewanti *et al*. (2018) that the dominant phytoplankton in the waters comes from the Bacillariophyceae class. This phytoplankton has a high tolerance to extreme conditions so that it can be found in freshwater and seawater. In addition, Bacillariophyceae also has high reproductive power which affects the increase in phytoplankton abundance. Another genus found in the waters of Labakkang District is Coscinodiscus. The *Coscinodiscus* group can also increase the value of dissolved oxygen in waters (Rahma *et al*., 2020). *Skeletonema* is a genus of the Bacillariophyceae class found at all stations. This genus can also survive in waters with salinities reaching 40 ppt (Rudiyanti, 2011).

The Dinophyceae class has less abundance than the Bacillariophyceae class. Light intensity affects the photosynthesis process carried out by Dinophyceae. The process also affects the pattern of Dinophyceae abundance in a water body. In addition, the abundance of Dinophyceae is also influenced by the presence of nitrate and phosphate in the water. Waters that have high nitrate levels cause low Dinophyceae abundance while waters that have low phosphate levels cause Dinophyceae abundance to tend to be high. However, phosphate content only has a small effect on the abundance of Dinophyceae in the waters (Tasak *et al.*, 2015).

Dinophysis is the second highest genus after *Chaetoceros* and is found at all water stations. This genus can produce okadaic toxins that can cause diarrhea, nausea/vomiting, abdominal pain, cramps and chills. Genera from the Dinophyceae class that are also harmful to health are *Protoperidinium*, *Ceratium*, and *Noctiluca* (Mujib *et al*., 2015).

Cyanophyceae and Chlorophyceae classes were not found in the waters of Labakkang District. This is in accordance with the statement of Munthe *et al.* (2012) that Cyanophyceae phytoplankton are very rarely found in the waters. Zikriah *et al.* (2020) added that generally Chlorophyta is dominantly found in fresh waters because it can adapt and develop in waters with sufficient light intensity.

The results of one way anova analysis for each parameter show that there are significant differences in temperature, salinity and Total Suspended Solid (TSS) parameters for each station. Significant temperature differences occur between station I and station III, station I and station IV and station II and station III. Significant differences in salinity occur between station I and other stations. In the Total Suspended Solid (TSS) parameter, there is a significant difference between station II and station III, station II and station IV and station I and station IV.

Phytoplankton abundance between stations has a significant difference. This can be seen from the results of the one way anova analysis which shows that the abundance of phytoplankton at station III and station IV has no significant difference. In addition, the abundance of phytoplankton between station I, station II and station IV also has no significant difference. Phytoplankton abundance is significantly different between station I and station III and at station II and station III. Based on the results of parameter measurements and multiple linear regression analysis, it shows that the parameters of temperature, nitrate and Total Suspended Solid (TSS) have a significant effect on phytoplankton abundance in the waters of Labakkang District.

The correlation coefficient (R) value of 0,963 indicates that the parameter correlation is very strong. This is in accordance with Yanasari *et al.* (2017) which says that correlation values ranging from >0,75-0,99 have a very strong correlation. The coefficient of determination (R2) was 0,928 (92,8%). This value indicates that the abundance of phytoplankton can be explained by the variables of temperature, nitrate and Total Suspended Solid (TSS) by 92,8% while 7,2% is influenced by other influential factors other than temperature, nitrate and Total Suspended Solid (TSS).

CONCLUSION

It is concluded that the physico-chemical parameters in the waters of Labakkang District are classified as suitable for phytoplankton growth. However, at station I (estuary area) phytoplankton can grow and develop better than other stations seen from the abundance of phytoplankton higher at station I (estuary area). The results of one-way anova analysis show that the parameters of temperature, salinity and Total Suspended Solid (TSS) are significantly different between stations. The results of multiple regression analysis show three parameters that have a significant effect on phytoplankton abundance including temperature, nitrate and Total Suspended Solid (TSS).

REFERENCES

Alimby, W. V. A., & Triajie, H. 2021. Tingkat Keasaman Pesisir Perairan Kamal Kabupaten Bangkalan Madura pada Musim Peralihan. Juvenil, Vol. 2, No. 3: 186–201.

Anisah, S. 2017. Kaitan Konsentrasi Nitrat (NO_3) dan Fosfat (PO_4) dengan Klorofil-a dari Fitoplankton pada Kondisi Lingkungan Perairan yang Berbeda di Pundata Baji, Kabupaten Pangkep. Skripsi Fakultas Ilmu Kelautan dan Perikanan Universitas Hasanuddin. Makassar.

APHA (*American Public Health Association*). 2005. Standard Methods for the Examination of Water and Wastewater Including Bottom Sediment and Sludges. Amer. Publ.17th Edition. New York Health Association.

Cokrowati, N., Amir, S., Abidin, Z., SetyoNo, B.D.H., & Damayanti, A.A. 2014. Kelimpahan dan Komposisi Fitoplankton di Perairan Kodek Pemenang Lombok Utara. Depik, Vol. 3, No. 1: 21-26.

Darmawan, A., SulardioNo, B., & Haeruddin. 2018. Analisis Kesuburan Perairan Berdasarkan Kelimpahan Fitoplankton, Nitrat dan Fosfat di Perairan Sungai Bengawan Solo Kota Surakarta. Journal of Maquares, Vol. 7, No. 1: 1–8.

Dewanti, L. P. P., Nyoman, I. D., Putra, I. D. N. N., & Faiqoh, E. 2018. Hubungan Kelimpahan dan Keanekaragaman Fitoplankton dengan Kelimpahan dan Keanekaragaman Zooplankton di Perairan Pulau Serangan, Bali. Journal of Marine and Aquatic Sciences, Vol. 4, No. 2: 324–335.

Fauzan, A.R., Yusuf M., & Maslukah L. 2015. Studi Sebaran Konsentrasi Nitrat dan Fosfat di Perairan Teluk Ujungbatu Jepara. Jurnal Oseanografi, Vol. 4, No. 2: 386-398.

Ferreira, A., Sa, C., Silva, N., Beltran, C., Dias, A., & Brito, A. 2020. Phytoplankton Response to Nutrient Pulses in An Upwelling System Assessed Through a Microcosm periment (Algarrobo Bay, Chile). Ocean and Coastal Management.

Helfinalis, Sultan & Rubiman. 2012. Padatan Tersuspensi Total di Perairan Selat Flores Boleng Alor dan Selatan Pulau Adonara Lembata Pantar. Jurnal Ilmu Kelautan, Vol. 17, No. 3: 148-153.

Herawati, H., Dhahiyat, Y., & Zahidah. 2017. Restocking Ikan Mola (*Hypophthalmichthys Molit*, Valenciennes 1844) di Waduk Cirata sebagai Upaya Pengendalian Kelimpahan Plankton. Jurnal Akuatika Indonesia, Vol. 2, No. 1: 95–101.

Hertika, A.M.S., Arsad, S., & Putra, R.B.D. 2021. Ilmu Tentang Plankton dan Peranannya di Lingkungan Perairan. UB Press. Indonesia.

Idrus, S. W. A. 2018. Analisis Kadar Karbon Dioksida di Sungai Ampenan Lombok Carbon. Jurnal Pijar MIPA, Vol. 13, No. 2: 167–170.

Juadi, Dewiyanti, I., & Nurfadillah. 2018. Komposisi Jenis dan Kelimpahan Fitoplankton di Perairan Ujong Pie Kecamatan Muara Tiga Kabupaten Pidie. Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsyiah, Vol. 3, No. 1: 112–120.

Meiriyani, F., Ulqadry, T. Z., & Putri, W. A. E. 2011. Komposisi dan Sebaran Fitoplankton di Perairan Muara Sungai Way Belau, Bandar Lampung. Maspari Journal, Vol. 03: 69–77.

Mujib, A. S., Damar, A., & WardiatNo, Y. 2015. Distribusi Spasial Dinoflagellata Planktonik di Perairan Makassar, Sulawesi Selatan. Jurnal Ilmu dan Teknologi Kelautan Tropis Vol. 7, No. 2: 479–492.

Munthe, Y. V., Aryawati, R., & Isnaini. 2012. Struktur Komunitas dan Sebaran Fitoplankton di Perairan Sungsang Sumatera Selatan. Maspari Journal, Vol. 4, No. 1: 122–130.

Mustafa, A., Utojo, Hasnawi, & Rachmansyah. 2006. Validasi Data Luas Lahan Budidaya Tambak di Kabupaten Maros dan Pangkep, Provinsi Sulawesi Selatan dengan Menggunakan Teknologi Penginderaan Jauh dan Sistem Informasi Geografis. Jurnal Riset Akuakultur, Vol. 1, No. 3: 419–430.

Mustofa, A. 2015. Kandungan Nitrat dan Pospat Sebagai Faktor Tingkat Kesuburan Perairan Pantai. Jurnal DISPROTEK, Vol. 6, No. 1: 13–19.

Nurfadilah, Rani, C., & Lukman, M. 2020. Kelimpahan Jenis Plankton di Perairan Muara Sungai Pangkep Sulawesi Selatan. Manfish Journal, Vol. 1, No. 2: 58–62.

Paiki, K., & Kalor, J. D. 2017. Distribusi Nitrat dan Fosfat Terhadap Kelimpahan Fitoplankton di Perairan Pesisir Yapen Timur. Journal of Fisheries and Marine Science, Vol. 1, No. 2: 65–71.

Permatasari, R. D., Djuwito, & Irwani. 2016. Pengaruh Kandungan Nitrat dan Fosfat Terhadap Kelimpahan Diatom di Muara Sungai Wulan, Demak. Diponegoro Journal Of Maquares, Vol. 5, No. 4: 224–232.

Rahma, Y. A., Wihelmina, G., Sugireng, & Ardiyati, T. 2020. Diversitas Mikroalga pada Berbagai Kedalaman Perairan Pantai Sendang Biru, Malang Jawa Timur. Biotropika, Vol. 8, No. 3: 135–143.

Ramdan, M. R., & Nuraeni, E. 2021. Identifikasi Morfologi *Ulva intestinalis* dan *Acanthophora spicifera* di Kawasan Pantai Tanjung Layar, Sawarna, Bayah, Kabupaten Lebak, Banten. Tropical Bioscience: Journal of Biological Science, Vol. 1, No. 1: 1–10.

Riandi, R., Apriansyah, & Risko. 2022. Pengukuran Kecepatan Arus Permukaan dengan Metode Langrangian di Estuari Mempawah. Manfish Journal, Vol. 2, No. 2: 72–79.

Ridho, M. R., PatrioNo, E., & Mulyani, Y. S. 2020. Hubungan Kelimpahan Fitoplankton, Konsentrasi Klorofil-a dan Kualitas Perairan Pesisir Sungsang, Sumatera Selatan Correlation. Jurnal Ilmu dan Teknologi Kelautan Tropis Vol. 12, No. 1: 1–8.

Rudiyanti, S. 2011. Pertumbuhan *Skeletonema costatum* pada Berbagai Tingkat Salinitas Media. Jurnal Saintek Perikanan, Vol. 6, No.2: 69-76.

Ruslaini, W. & Iba. 2011. Studi Kondisi Kualitas Air Budidaya Rumput Laut (*Gracilaria verrucosa*) pada Tambak Tanah Sulfat Masam (Studi Kasus di Kecamatan Moramo, Kabupaten Konawe Selatan, Provinsi Sulawesi Tenggara). Aqua Hayati, Vol. 7, No. 3: 189 – 195.

Sabran, M., Mamu, H. D., & Tangge, L. N. 2016. Struktur Komunitas Plankton di Perairan Teluk Palu dan Pemanfaatannya sebagai Sumber Belajar. Jurnal Sains dan TekNologi Tadulako, Vol. 5, No. 2: 16–27.

Sari, D. R., Hidayat, J. W., & Hariyati, R. 2017. Struktur Komunitas Plankton di Kawasan Wana Wisata Curug Semirang Kecamatan Ungaran Barat, Semarang. Jurnal Biologi, Vol. 6, No. 2: 50–57.

Tambaru, R., Muhiddin, A. H., & Malida, H. S. 2014. Analisis Perubahan Kepadatan Zooplankton Berdasarkan Kelimpahan Fitoplankton pada Berbagai Waktu dan Kedalaman di Perairan Pulau Badi Kabupaten Pangkep. Torani (Jurnal Ilmu Kelautan dan Perikanan), Vol. 24, No. 3: 40–48.

Tasak, A. R., Kawaroe, M., & PrartoNo, T. 2015. Keterkaitan Intensitas Cahaya dan Kelimpahan Dinoflagellata di Pulau Samalona, Makassar. Ilmu Kelautan Vol. 20, No. 2: 113–120.

Yanasari, N., Samiaji, J., & Siregar, S. H. 2017. Struktur Komunitas Fitoplankton di Perairan Muara Sungaitohor Kabupaten Kepulauan Meranti Provinsi Riau. Fakultas Perikanan dan Ilmu Kelautan Universitas Riau.

Zikriah, Bachtiar, I., & Japa, L. 2020. The Community of Chlorophyta as Bioindicator of Water Pollution in Pandanduri Dam District of Terara East Lombok. Jurnal Biologi Tropis, Vol. 20, No. 3: 546–555.