

WATER QUALITY ANALYSIS ON PHYTOPLANKTON ABUNDANCE AS A BIOINDICATOR OF MARINE WATER TROPHIC STATUS

Analisis Kualitas Perairan Terhadap Kelimpahan Fitoplankton Sebagai Bioindikator Kesuburan Perairan Laut

Ayu Mariati Hutabarat¹, Munandar^{1,2*}, Muhammad Rizal²

¹Marine Science Study Program, Faculty of Fisheries and Marine Science, Teuku Umar University, ² Master's Program in Fisheries Science, Faculty of Fisheries and Marine Science, Teuku Umar University

Jln. Alue Peunyareng, Ujong Tanoh Darat, Meureubo, West Aceh Regency, Aceh

*Corresponding author: munandar@utu.ac.id

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ABSTRACT

Phytoplankton is an organism that plays an important role as an oxygen producer and a measure of water pollution. Phytoplankton activity is strongly influenced by water quality parameters such as temperature, pH, light intensity, current speed, nitrate, phosphate, DO, BOD and salinity. However, studies on the analysis of water quality studies on phytoplankton abundance are still little implemented in Aceh waters. This study aims to analyze water quality, determine the type and abundance, diversity, uniformity, dominance of phytoplankton. Linear regression analysis was used to determine the relationship between environmental parameters on phytoplankton abundance, in the marine waters of Pulau Banyak District, Aceh Singkil Regency. This research was conducted in September-November 2024 in the waters of Baguk Island and Panjang Island, Pulau Banyak Subdistrict, Aceh Singkil Regency. Data collection using purposive sampling method based on the results of observations. From the results of the study obtained phytoplankton abundance in the waters of Baguk Island and Panjang Island amounted to 31.11 - 55.56 cells/L consisting of 28 genus which are divided into 5 classes namely Bacillariophyceae, Cyanophyceae, Dynophyceae, Oligotrichea, Zygnematophyceae. The ecological index in the waters of Baguk Island and Panjang Island consists of a diversity index (H') including the medium category, a uniformity index (E) including the high category and a dominance index (D) including the low category. Regression results show that the temperature parameter has a strong influence and relationship to phytoplankton abundance of 75.7%. While other parameters do not significantly affect phytoplankton. The waters of Baguk Island and Panjang Island are included in oligotrophic status and moderately polluted.

Keywords: Baguk Island, Diversity, Linear Regression, Panjang Island, Phytoplankton

ABSTRAK

Fitoplankton merupakan organisme yang berperan penting sebagai penghasil oksigen dan tolak ukur pencemaran perairan. Aktifitas fitoplankton sangat dipengaruhi oleh parameter kualitas air seperti suhu, pH, intensitas cahaya, kecepatan arus, nitrat, posfat, DO, BOD dan salinitas.

Namun kajian tentang analisis kajian kualitas perairan terhadap kelimpahan fitoplankton masih sedikit dilaksanakan dilokasi perairan Aceh. Penelitian ini bertujuan untuk menganalisis kualitas perairan, mengetahui jenis dan kelimpahan, keanekaragaman, keseragaman, dominansi fitoplankton. Analisis regresi linear digunakan untuk mengetahui hubungan antar parameter lingkungan terhadap kelimpahan fitoplankton, di perairan laut Kecamatan Pulau Banyak, Kabupaten Aceh Singkil. Penelitian ini dilaksanakan pada bulan September-November 2024 di perairan Pulau Baguk dan Pulau Panjang Kecamatan Pulau Banyak Kabupaten Aceh Singkil. Pengumpulan data menggunakan metode *purposive sampling* berdasarkan hasil observasi. Dari hasil penelitian diperoleh kelimpahan fitoplankton di perairan Pulau Baguk dan Pulau Panjang sebesar 31,11 - 55,56 sel/L terdiri dari 28 genus yang terbagi kedalam 5 kelas yaitu *Bacillariophyceae*, *Cyanophyceae*, *Dynophyceae*, *Oligotrichea*, *Zygnematophyceae*. Indeks ekologi pada perairan Pulau Baguk dan Pulau Panjang terdiri dari indeks keanekaragaman (H') termasuk kategori sedang, indeks keseragaman (E) termasuk kategori tinggi dan indeks dominansi (D) termasuk kategori rendah. Hasil regresi menunjukkan bahwa parameter suhu memiliki pengaruh dan hubungan yang kuat terhadap kelimpahan fitoplankton sebesar 75,7%. Sedangkan parameter lainnya tidak berpengaruh nyata terhadap fitoplankton. Perairan Pulau Baguk dan Pulau Panjang termasuk kedalam kesuburan oligotrofik dan tercemar sedang.

Kata Kunci: Keanekaragaman, Fitoplankton, Pulau Baguk, Pulau Panjang, Regresi Linear

INTRODUCTION

Pulau Banyak District is a group of small islands located in Aceh Singkil Regency, Aceh Province. The total area is 27,196 hectares. Banyak Island is located at the western tip of Sumatra Island, directly connected to the Indian Ocean. Pulau Banyak sub-district is an archipelagic area that has quite wide sea and very long and beautiful beaches that are not inferior to the beaches in Indonesia. Banyak Island has become a highlight for domestic and international tourists because of its beauty (Diva, 2021). Apart from tourism potential, Banyak Island also has economic potential from marine and fisheries products. Banyak Island has enormous marine resource potential. This can be seen from the high fish catch and the many types of fish caught by fishermen. On average, coastal communities on Banyak Island depend on fishermen for their livelihood (Amarullah *et al.*, 2023).

Sub-district area is a coastal ecosystem which is widely used for various human activities such as tourism activities, residential areas, aquaculture, ports, sea transportation routes and anchorages for fishing boats. Akbar & Pratiwi (2023) state that all human activities can increase the input load in the form of household waste and other anthropogenic waste. The influx of waste concentrations from both land and marine activities will have an impact on water quality both physically and chemically. A water condition is said to be polluted if nitrate and phosphate content is observed in very high concentrations (Saleky *et al.*, 2022). Mahaputra & Santoso (2018) stated that human activities can cause environmental changes which result in decreased water quality, thus potentially affecting the survival of marine organisms and those that consume this biota. Changes in water quality will affect the abundance of primary producers in the waters, namely phytoplankton. This is because phytoplankton are organisms that are sensitive to changes in the aquatic environment. So phytoplankton can be used as a biological indicator of water quality (Samudera *et al.*, 2021).

Phytoplankton plays an important role as a producer of oxygen and a measure of pollution in the aquatic environment. If the presence of phytoplankton in the waters is very low, it can have an impact on the next trophic level (Hendrajat & Sahrijanna, 2019). The existence and abundance of phytoplankton is also influenced by several other factors, namely sunlight, salinity, temperature, competition, growth rate and the grazing process. Water quality such as pH, temperature, light intensity, current speed, nitrate, phosphate, DO, BOD and salinity are

important components that can influence the activity of phytoplankton as primary producers in waters. Apart from that, diversity, dominance and uniformity are parameters that can be used to describe the structure of phytoplankton communities (Rahmah *et al.*, 2022). Phytoplankton has an important role in waters that has an impact on other biota. Because phytoplankton are primary producers connecting trophic levels in the food chain.

Seeing how important the role of phytoplankton is as primary producers and as bioindicators of aquatic trophic status, this research needs to be carried out to analyze water quality, determine the type and abundance, diversity, uniformity, dominance of phytoplankton, as well as a simple linear regression test to determine the relationship between environmental parameters and phytoplankton abundance, in the sea waters of Pulau Banyak District, Aceh Singkil Regency.

METHODS

Time and Place

This research was carried out from September 2023 to November 2024 in the waters of Baguk Island and Panjang Island, Pulau Banyak District, Aceh Singkil Regency. The method used in this research is descriptive quantitative method and observation. This research has two stages, namely taking samples in the field at the waters of Baguk Island and Panjang Island, Pulau Banyak District and data analysis (phytoplankton identification) at the Aquatic Environmental Productivity Laboratory at Teuku Umar University and nutrient analysis at the Industrial Research and Development Agency Laboratory, Research Center and Industrial Standardization (BARISTAND). The location of the research station is presented in Figure 1.

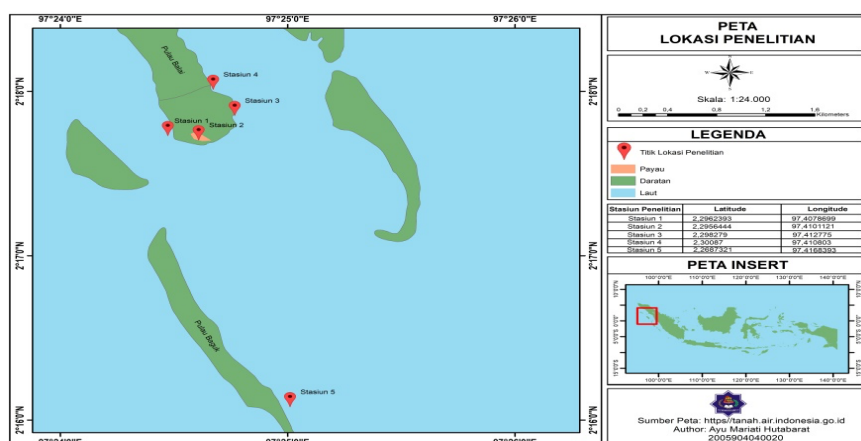


Figure 1. Map of Research Locations

Tools and Materials

This research uses materials in the form of lugol for sample preservation, phytoplankton samples for identification and data analysis, seawater (nutrient) samples for nitrate and phosphate tests, BOD, DO and distilled water to calibrate the equipment. The tools used are a refractometer for measuring salinity, thermometer for measuring temperature, pH meter for measuring pH, cool box for storing nutrients, plankton net for filtering phytoplankton, 100 ml sample bottle for storing phytoplankton samples, 10 L plastic bucket for taking phytoplankton samples, phytoplankton identification book for identifying phytoplankton, a secchi dish to measure brightness, an aqua bottle to store nutrient samples, a current kite to measure current speed and a light microscope to observe phytoplankton.

Research Procedure

Determination of Sampling Locations

Determination of sampling points uses the purposive sampling method. There are 6 research stations according to certain characteristics, namely station 1 (ferry port), station 2 (mangrove area), station 3 (fish cage area), station 4 (domestic waste disposal) and station 5 (Long Island tourist area).

Phytoplankton Sampling

Phytoplankton sampling was carried out by filtering a volume of 100 L of water using a 5 L bucket which was carried out 20 times horizontally using a 40 µm plankton net. The filtered water was put into a 100 ml sample bottle and preserved with Lugol's solution until brick red. Phytoplankton sampling was carried out 3 times per station. The preserved phytoplankton samples were observed at the Teuku Umar University Aquatic Environmental Productivity Laboratory using a Nikon Eclipse light microscope with magnifications of 4 x 0.10 and 10 x 0.25. The observation method uses the census method. The types of phytoplankton obtained were then observed, documented and identified based on morphological similarities referring to the book written by (Yamaji, 1979).

Measurement of Water Quality Parameters

Water quality measurements in the sea waters of Baguk Island and Panjang Island, Pulau Banyak District are carried out in situ and ex situ. Measurement of water quality parameters directly in the field (in situ), namely temperature, brightness, salinity, current speed and pH. Meanwhile, measurements of BOD, DO, nitrate and phosphate were carried out ex-situ, namely by taking 10 seawater samples (nutrient samples) from 5 stations, putting them into aqua bottles and labeling them with the sample station information. The seawater samples were put into a coolbox, then taken to the Industrial Research and Development Agency, Industrial Research and Standardization Center (BARISTAND) in Banda Aceh to measure the DO, BOD, nitrate and phosphate parameters. The results of the environmental parameter data obtained are then analyzed and linked to quality standards Menteri Negara Lingkungan Hidup, 2004).

Data Analysis

Data analysis of abundance, diversity index, uniformity index and phytoplankton dominance index was tabulated in Microsoft Excel 2010 and described descriptively. Calculation of phytoplankton abundance using the formula (APHA, 1989):

$$N = Z \times \frac{X}{Y} \times \frac{1}{V}$$

Where:

- N = abundance of individual phytoplankton (individuals/liter)
- Z = number of individual phytoplankton
- X = volume of filtered sample water
- Y = volume of 1 drop of water (0.06 ml)
- V = volume of filtered water

The phytoplankton diversity index used is the Shannon-Wiener diversity index (Odum, 1971):

$$H' = - \sum_{i=1}^S P_i \ln P_i$$

Where:

- H' = diversity index
- P_i = proportion of species i to the total community
- N_i = number of ith species
- N = total number of species
- S = number of types

Low diversity if H' < 1, medium diversity if 1 ≤ H' ≤ 3 and high diversity if H' > 3.

The uniformity index is calculated using the formula (Odum, 1971):

$$E = \frac{H'}{H' \text{ maks}}$$

Where:

- E = i uniformity index
 H' = i diversity index
 H' maks = maximum diversity value

The uniformity index (E) ranges from 0-1. An E value that is close to 1 indicates an even distribution of individuals between types and if the E value is close to 0 then the distribution of individuals between types is uneven and there is dominance of one type (Odum, 1971).

The formula used to calculate Simpson dominance is according to (Odum, 1998). Dominance by certain species in the population as in the following formula:

$$C = \sum (ni/N)^2$$

Where:

- C = dominance index
 ni = Number of individuals of type i
 N = Total number of individuals

The C value ranges from 0 to 1, if the C value is close to 0 it means that almost no individuals dominate and if the C value is close to 1 it means that one of the genera dominates (Odum, 1998). Meanwhile, to determine the relationship between water quality and phytoplankton abundance, regression analysis was carried out using SPSS 18. This aims to determine the relationship and influence between water quality (independent variable) on the abundance of phytoplankton (dependent variable). The data analysis used is simple linear regression analysis by inputting the Trust variable as an independent variable, namely water quality (X) and participation as the dependent variable, namely phytoplankton abundance (Y) using the Enter method.

RESULT

Water Parameter Results

Water quality measurements are carried out in situ and out situ. The parameters temperature, brightness, pH, salinity and current speed were measured in situ while DO, nitrate, phosphate and BOD were measured ex situ. The results of measurements of the physical and chemical parameters of the sea waters of Baguk Island and Panjang Island, Pulau Banyak District during the research are shown in Table 1.

Table 1. Results of Water Quality Parameters

Parameters Measured	Unit	Station					Quality Standards
		1	2	3	4	5	
Temperature	°C	28.5	29.6	29.8	30.6	27.7	28-32
Brightness	m	1.43	0.65	1	1	1	>5
Nitrate	mg/L	1	1	0.8	0.9	1,2	0.008
Phosphates	mg/L	0.1	0.26	0.07	0.18	0.006	>0.015
DO	mg/L	5.13	5.33	5.54	5.49	5.74	>5
pH	-	9.5	9.67	9.3	9.1	9.6	7-8.5
Salinity	ppt	30	5	27	24	33	33-34
BOD	mg/L	2.05	1.85	0.41	0.82	0.62	<20 mg/L
Flow Speed	m/s	0.03	0.01	0.04	0.01	0.04	-

Quality standards based on Minister of Environment Decree No. 51 of 2004 for marine biota

Phytoplankton Identification

From 6 research stations, 37 species of 28 phytoplankton genera were found which were divided into 5 classes, namely the *Bacillariophyceae class* (16 genera), the *Cyanophyceae class* (4 genera), the *Dynophyceae class* (4 genera), the *Oligotrichea class* (2 genera) and the *Zygnematophyceae class* (2 genera). The composition of phytoplankton types that were always found at each station during observations was dominated by diatom groups from the *Bacillariophyceae class*, namely the genera *Synedra* and *Leptocylindrus*. The composition of phytoplankton is presented in Figure 2., while the types of phytoplankton are presented in Table 2.

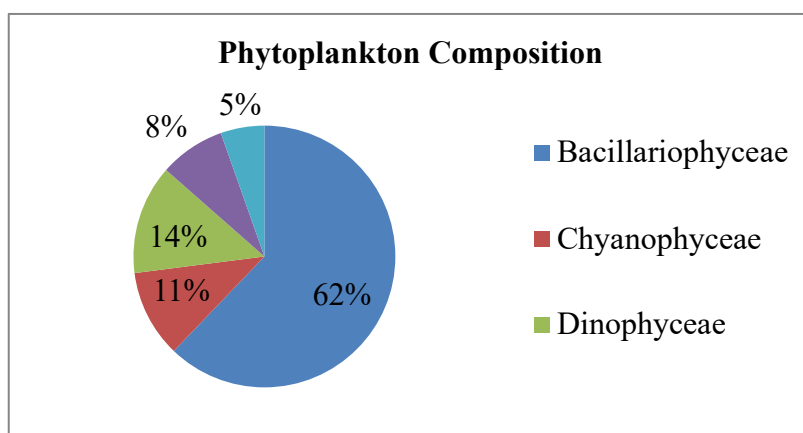


Figure 2. Phytoplankton Composition Based on The Abundance of Phytoplankton Types in The Waters of Pulau Banyak District

Table 2. Results of Phytoplankton Identification in The Waters of Baguk Island and Panjang Island

Class	Family	Genus	Species
BACILLARIOPHYCEAE	Chaetocerotaceae	<i>Chaetoceros</i>	<i>Chaetoceros compressum</i>
			<i>Chaetoceros affine</i>
	Climacospheniaceae	<i>Climacosphenia</i>	<i>Climacosphenia</i> sp.
	Stephanodiscaceae	<i>Cyclotella</i>	<i>Cyclotella</i> sp.
	Rhopalodiaceae	<i>Epithemia</i>	<i>Epithemia argus</i>
	Gomphonemataceae	<i>Ghomponema</i>	<i>Ghomponema</i> sp.
	Biddulphiaceae	<i>Isthmia</i>	<i>Isthmia</i> sp.
	Leptocylindraceae	<i>Leptocylindrus</i>	<i>Leptocylindrus danicus</i>
			<i>Leptocylindrus minimus</i>
			<i>Leptocylindrus</i> sp.
	Mastogloiaceae	<i>Mastogloia</i>	<i>Mastogloia</i> sp.
	Melosiraceae	<i>Melosira</i>	<i>Melosira varians</i>
	Bacillariales	<i>Nitzschia</i>	<i>Nitzschia linearis</i>
			<i>Nitzschia</i> sp.
Pleurosigmaaceae	<i>Pleurosigma</i>	<i>Pleurosigma</i> sp.	
Rhabdonemataceae	<i>Rhabdonema</i>	<i>Rhabdonema adriaticum</i>	
		<i>Rhabdonema</i> sp.	
Rhizosoleniaceae	<i>Rhizosolenia</i>	<i>Rhizosolenia setigera</i>	

Class	Family	Genus	Species
			<i>Rhizosolenia borealis</i>
			<i>Rhizosolenia sp.</i>
	Skeletonemataceae	<i>Skeletonema</i>	<i>Skeletonema sp.</i>
	Fragilariaceae	<i>Synedra</i>	<i>Synedra needle</i>
			<i>Synedra sp.</i>
			<i>Synedra ulna</i>
	Thalassionemataceae	<i>Thalassionema</i>	<i>Thalassionema nitzschioides</i>
CYANOPHYCEAE	Oscillatoriaceae	<i>Lyngbya</i>	<i>Lyngbya sp.</i>
		<i>Oscillators</i>	<i>Oscillatoria sp.</i>
	Merismopediaceae	<i>Merismopedia</i>	<i>Merismopedia sp.</i>
DINOPHYCEAE	Stigonemataceae	<i>Stigonema</i>	<i>Stigonema sp.</i>
	Ceratiaceae	<i>Ceratium</i>	<i>Ceratium fork</i>
			<i>Ceratium minute</i>
	Gonyaulacaceae	<i>Gonyaulax</i>	<i>Gonyaulax spinifera</i>
	Gymnodiniaceae	<i>Gymnodinium</i>	<i>Gymnodinium sp.</i>
	Prorocentraceae	<i>Pronocentrum</i>	<i>Pronocentrum micane</i>
OLIGOTRICHEA	Rhabdonellidae	<i>Rhabdonella</i>	<i>Rhabdonella sp.</i>
	Codonellidae	<i>Tintinnopsis</i>	<i>Tintinnopsis corniger</i>
			<i>Tintinnopsis sp.</i>
ZYGNEMATOPHYCEAE	Desmidiaceae	<i>Pleurotaenium</i>	<i>Pleurotaenium trabecula</i>
	Zygnemataceae	<i>Spyrogyra</i>	<i>Spyrogyra sp.</i>

Phytoplankton Abundance

The phytoplankton abundance obtained was 31.11 - 55.56 cells/L. The highest abundance was at station 4 at 55.56 cells/L. Meanwhile, the lowest abundance was at station 5 at 31.11 cells/L. The abundance of phytoplankton is presented in Figure 3.

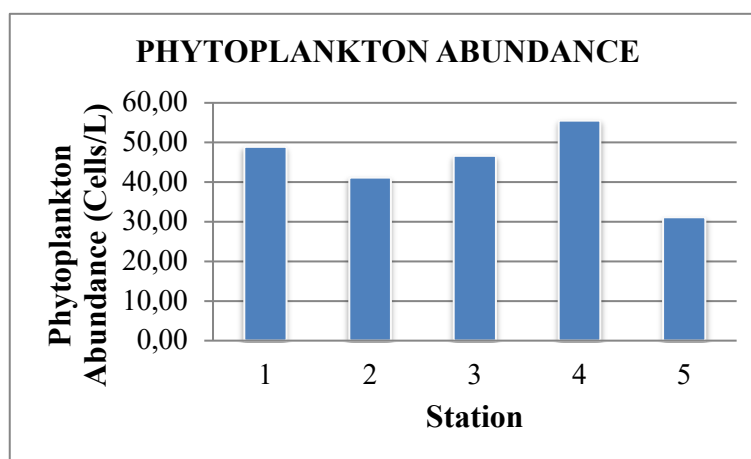


Figure 3. Phytoplankton Abundance

Diversity Index, Uniformity Index and Dominance Index

As a result of analysis of the data obtained, it is known that the phytoplankton diversity index in the waters of Banyak Island ranges from 1.8 -2.6, included in the medium diversity category with a value of $1 \leq H' \leq 3$, which means that the stability of the community is also moderate. The phytoplankton uniformity index value ranges from 0.76 -0.88. This illustrates that the uniformity index is relatively high and the distribution between species is even. The phytoplankton dominance index value from all stations ranges between 0.10 -0.24, meaning it is close to 0. The dominance index value is classified as low dominance. According to calculations using the Simpson dominance formula, it is explained that if the dominance index is $0 < D \leq 0.5$ then there is no genus that dominates and if the dominance index value is $0.5 < D \leq 1$ then there is a genus that dominates. The results of the dominance index, diversity index and uniformity index are presented in Figure 4.

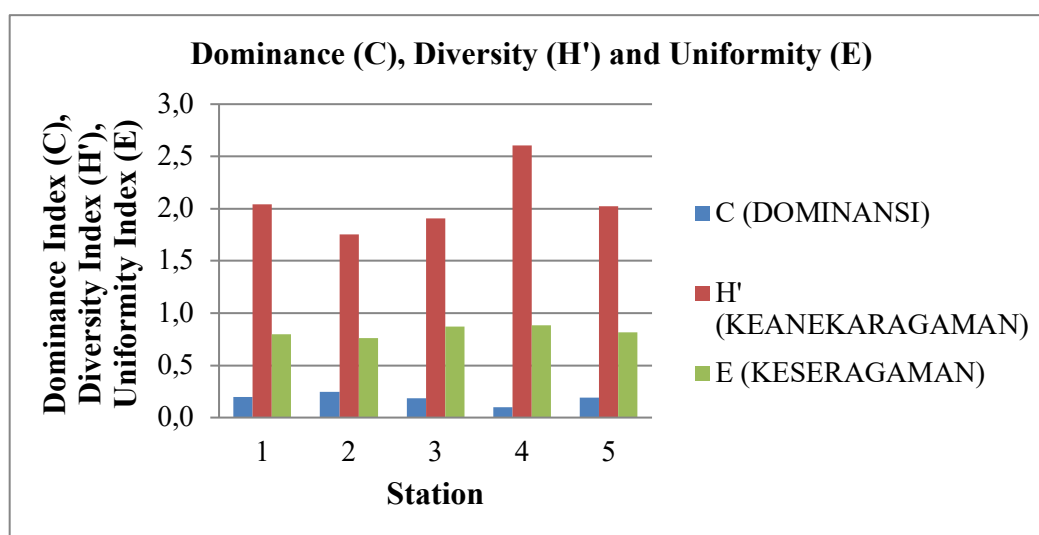


Figure 4. Dominance, Diversity and Uniformity of phytoplankton

Relationship between Water Quality Parameters and Phytoplankton Abundance

The results of the linear regression test obtained by the coefficient of determination (R Square) and significance through the ANNOVA test are presented in Table 3.

Table 3. Regression test results based on coefficient of determination and significance

No	Predictors (X)	Dependent Variable (Y)	R Square	Sig.
1	Temperature (X1)	Phytoplankton Abundance	0.757	0.05
2	Brightness (X2)	Phytoplankton Abundance	0.091	0.62
3	Nitrate (X3)	Phytoplankton Abundance	0.595	0.13
4	Phosphate (X4)	Phytoplankton Abundance	0.175	0.48
5	DO (X5)	Phytoplankton Abundance	0.254	0.39
6	Ph (X6)	Phytoplankton Abundance	0.617	0.12
7	Salinity (X7)	Phytoplankton Abundance	0.003	0.93
8	BOD (X8)	Phytoplankton Abundance	0.016	0.84
9	Current Speed (X9)	Phytoplankton Abundance	0.222	0.42

DISCUSSION

The results of measuring water quality still meet the quality standards for marine biota based on Kep.51/MENKLH/2004, namely the temperature at stations 1, 2, 3 and 4 ranges from 28.5 to 30.6. Meanwhile, the temperature at station 5 of 27.7 does not meet the quality

standards, but is still considered optimal for the survival of phytoplankton. Kadir *et al.* (2015) stated that the optimum temperature for the survival of phytoplankton is in the range of 25-30°C. The low temperature at station 5 is thought to be due to the environmental conditions when the samples were measured when it was raining. Several factors such as weather conditions, sampling time and sampling location can influence the high and low temperatures in the measurement results (Zainuri *et al.*, 2023). The brightness values at all stations do not meet quality standards, but are classified as optimal for phytoplankton. This is confirmed by Suardiani *et al.* (2018), stating that the optimal water brightness for aquatic organisms is around >45 cm. The nitrate concentration at all research stations ranges from 0.8 to 1.2 mg/L and does not meet the quality standards for marine biota, because it is relatively high. However, the nitrate value obtained is still optimal for phytoplankton growth. According to Gurning *et al.* (2020), states that the nitrate concentration required by phytoplankton on average ranges from 0.9-3.5. The high concentration of nitrates is thought to be due to the presence of waste from the community and animal waste. In agreement with Putri *et al.* (2019), the main source of nitrate comes from household and agricultural waste, including animal and human waste. The phosphate content obtained ranged from 0.006 to 0.26 mg/L. The phosphate content found in the waters of station 1, station 2, station 3, station 4, station 5 is classified as optimal for phytoplankton productivity and is in accordance with Menteri Negara Lingkungan Hidup (2004) which sets the standard value for phosphate at >0.015 mg/L. Meanwhile, the phosphate content in station 6 waters does not meet quality standards because the value is only 0.006. The low phosphate levels at station 6 suggest that this area is not a residential area, so it does not receive a lot of input loads such as domestic waste and pond waste. Widyastuti *et al.* (2015) stated that phosphate compounds are obtained from household waste and organic waste. The DO levels obtained ranged from 5.13-5.74 mg/L, this value meets the quality standards, namely >5 mg/L and is optimal for phytoplankton productivity. The pH value is classified as high, namely around 9.1-9.67, this value does not meet quality standards and is not ideal for phytoplankton life. Gurning *et al.* (2020) stated that the optimum degree of acidity (pH) for phytoplankton life ranges from 6.5-8.0. The salinity obtained ranged from 5-33 ppt, the salinity values at stations 1, 2, 3 and 4 did not meet the quality standards, while the salinity at station 5 was 33 ppt according to the quality standards. A good salinity for phytoplankton growth is around 10-40 ppt (Raymond, 1980). It can be concluded that the salinity at stations 1, 3 and 4 is still relatively good for phytoplankton growth. There is a drastic difference in salinity values at station 2, namely 5 ppt, which is very different from the other stations. This is because station 2 is brackish water. The BOD values obtained ranged from 0.62 -2.05, relatively low and still within the quality standard limit, namely <20 mg/L. BOD levels are closely related to DO levels in the water, if DO levels are high then BOD levels are low. From the DO and BOD measurements obtained, it is known that the DO levels are greater than the BOD levels. This can also indicate that the waters of Banyak Island are included in the unpolluted category. Daroini *et al.* (2020) states that the high BOD content reflects the low DO levels contained in the waters. Tamyiz (2015) also stated that the level of pollution can be seen from the presence of BOD, the higher the oxygen use, the lower the remaining amount of DO. Based on quality standards, water quality is not polluted (good category) if the standard BOD value in the minimum sample is <3 (Pemerintah Republik Indonesia, 2001). The current speed in the waters of Baguk Island and Panjang Island is classified as very weak, namely around 0.01-0.04 m/s. Risnawati *et al.* (2018), stated that current speed is divided into 3 categories, namely waters with very strong currents (>1 m/s), strong (0.5–1 m/s), moderate (0.25–0.5 m/s), weak (0.1–0.2 m/s) and very weak (<0.1 m/s).

The composition of the Bacillariophyceae class is more commonly found in the waters of Pulau Banyak District than Chyanophyceae, Dinophyceae, Oligotricea and Zynematophyceae. This is because the water environmental conditions at the research station

are suitable for the survival of phytoplankton from the Bacillariophyceae class. Aiso (2019) stated that many classes of Bacillariophyceae (diatoms) are found in waters because they are able to adapt to the environment, tolerate extreme conditions, are cosmopolitan, and have high reproductive abilities compared to other phytoplankton classes. Rahmah *et al.* (2022) also stated that Bacillariophyceae is a group of phytoplankton that is able to tolerate and adapt to waters with fairly high temperature conditions.

The types of phytoplankton that were always found at each station during observations were dominated by diatom groups from the Bacillariophyceae class, namely the genera *Synedra* and *Leptocylindrus*. *Synedra* is a genus of Bacillariophyceae which can be used as a biological indicator in waters. *Synedra* is a group of diatoms that are able to adapt to extreme environments and can describe the situation of polluted waters when their productivity is superior to other types of phytoplankton (Isti'anah *et al.*, 2015). Apart from *synedra*, the genus *Leptocylindrus* is also always found at every research station. *Leptocylindrus* can also be used as a biological indicator because it has the strength to survive in all situations. Juadi *et al.* (2018) stated that phytoplankton can be called indicators if they are able to dominate in all conditions in a particular environment.

Phytoplankton abundance obtained ranged from 31.11 - 55.56 cells/L. Based on the results of phytoplankton abundance obtained from 5 observation stations, it shows that the waters of Baguk Island and Panjang Island are included in oligotrophic waters. Nastiti & Hartati (2013) stated that based on the abundance of phytoplankton, waters are classified into 3 categories, namely waters with a low level of trophic status with an abundance of phytoplankton ranging from 0-2000 cells/L including the oligotrophic category, a moderate level of trophic status with an abundance of phytoplankton ranging from 2,000-15,000 cells/L is the mesotrophic category. Meanwhile, waters with an abundance of phytoplankton of more than 15,000 cells/L are waters with a high level of trophic status, namely the eutrophic category. The low abundance of phytoplankton is thought to be due to the influence of the size of the plankton net used. Based on Wandira (2016) entitled "The relationship between the distribution of phytoplankton abundance and the concentration of chlorophyll-A in the coastal and marine waters of Pangkajene Islands Regency" states that the abundance of phytoplankton is higher when using plankton net 25 μM compared to plankton net 55 μM . It can be concluded that apart from water quality factors, the size of the plankton net also influences the abundance of phytoplankton obtained.

The diversity index value in the waters of Baguk Island and Banyak Island ranges from 1.8 -2.6. According to the Shanon-Wiener index, this diversity value is classified as moderately polluted waters ($1 < H' < 3$) (Dimenta *et al.*, 2020). An indicator that indicates that the waters of Pulau Banyak District are polluted is the discovery of several phytoplankton genera such as *Nitzschia*, *Chaetoceros* and *Ceratium*. Gurning *et al.* (2020) stated Several dangerous phytoplankton genera that live in waste-polluted waters are *Skeletonema*, *Chaetoceros*, *Ceratium*, *Dinophysis*, *Nitzschia*, *Peridium* and *Pseudonitzschia*.

The uniformity index value in the waters of Banyak Island ranges from 0.76 -0.88. This value is classified as high species uniformity and an even distribution of individuals between species. Odum (1971), stated that if the uniformity index (E) value is close to 1, then the distribution of individuals between species is even. If the uniformity value (E) is close to 0, then the distribution of individuals between species is uneven and there is dominance of a certain species.

The phytoplankton dominance index value from all stations ranges between 0.10 -0.24. The dominance index value is classified as low dominance with a value of $0.5 < D \leq 1$. According to calculations using the Simpson dominance formula, it is explained that if the dominance index is $0 < D \leq 0.5$ then there is no dominant genus and if the dominance index value is $0.5 < D \leq 1$ then there is a genus that dominates (Odum, 1989). The dominance index

value is related to the uniformity index, if the uniformity index is high then the dominance index is low. Samudera *et al.* (2021), the higher the species uniformity, the smaller the dominance value, meaning that no particular species dominates.

Based on the results of the analysis of the coefficient of determination (R Square), the water quality parameter that has a strong influence and relationship on phytoplankton abundance is temperature of 0.757. Meanwhile, the other parameters have a relationship (R Square), namely brightness 0.091 (very weak), nitrate 0.595 (medium), phosphate 0.175 (very weak), DO 0.254 (weak), pH 0.617 (medium), salinity 0.003 (very weak), BOD 0.016 (very weak) and current speed 0.222 (weak) against phytoplankton. Mutaqin *et al.* (2014) stated that the relationship or closeness values were categorized as (0.00-0.20) very weak relationship, (0.21-0.40) weak relationship, (0.41-0.70) strong relationship. moderate, (0.71–0.90) strong relationship, and (0.91–1.00) very strong relationship. Through the ANNOVA test, the significance values obtained for the parameters brightness, nitrate, phosphate, DO, pH, salinity, BOD and current speed were >0.05 . This indicates that brightness, , nitrate, phosphate, DO, pH, salinity, BOD, and current speed have no significant effect on phytoplankton abundance. Meanwhile, temperature with a sig value of $0.05 = 0.05$ is still considered close to the probability value, which means that temperature influences the abundance of phytoplankton. The results of the coefficient of determination and significance explain that the abundance of phytoplankton is influenced by temperature. The R^2 value between temperature and phytoplankton abundance is 0.757, meaning that the effect of temperature on phytoplankton is 75.7%. Meanwhile, the other 24.3% was influenced by other factors. This is also proven by the composition of phytoplankton which is dominated by the Bacillariophyceae class, that temperature influences the presence of phytoplankton. This is reinforced by the statement that temperature is a factor that influences the presence of Bacillariophyceae (diatoms) in waters. The regression results show that an increase in temperature will be followed by an increase in phytoplankton. Rahmah *et al.* (2022) stated that high temperatures can increase the rate of photosynthesis, support the digestive process, accelerate cell division and phytoplankton respiration.

CONCLUSION

The abundance of phytoplankton in the waters of Baguk Island and Panjang Island is 31.11 - 55.56 cells/L consisting of 28 phytoplankton genera which are divided into 5 classes, namely *Bacillariophyceae* (16 genera), *Cyanophyceae* (4 genera), *Dynophyceae* (4 genera), *Oligotrichea* (2 genera) and *Zygnematophyceae* (2 genera). The ecological index in the waters of Baguk Island and Panjang Island consists of the diversity index (H') which is in the medium category, the uniformity index (E) which is in the high category and the dominance index (D) which is in the low category. Based on abundance, the trophic status level of waters is classified as oligotrophic (low). Meanwhile, water quality is based on the diversity index, BOD value and phytoplankton genus found, the waters of Baguk Island and Panjang Island are included in the moderately polluted category. The results of simple linear regression analysis show that the abundance of phytoplankton in the waters of B aguk Island and Panjang Island, Pulau Banyak District is influenced by several factors, one of which is temperature. Temperature influences phytoplankton abundance by 75.7 % with R^2 of 0.757, both of which have a strong relationship. Meanwhile, other factors such as brightness, nitrate, phosphate, BOD, DO, pH, salinity and current speed have a very weak, weak and moderate relationship to phytoplankton and do not have a significant effect on phytoplankton abundance.

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