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The relationship between nitrate and phosphate nutrients and phytoplankton abundance in coastal waters: Implications for ecosystem dynamics

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ABSTRACT

Background: The presence and abundance of phytoplankton are closely related to the physical and chemical parameters of water. Phytoplankton play a crucial role in aquatic ecosystems as primary producers and nutrient absorbers. This study aims to analyze the relationship between nitrate and phosphate nutrient content and the abundance of phytoplankton in the Arungkeke Waters, Jeneponto Regency. **Methods:** This research utilized a combination of field measurements and laboratory analysis. Direct measurements in the Arungkeke waters were conducted to assess surface water parameters, including temperature, salinity, current velocity, transparency, and ph. Water samples were collected for laboratory analysis of phytoplankton composition and abundance, as well as nitrate and phosphate concentrations. Regression analysis was performed to determine the relationship between nutrient concentrations and phytoplankton abundance. **Findings:** The study identified two classes of phytoplankton present in the Arungkeke waters: Bacillariophyceae and Dinophyceae. Oceanographic parameters were measured, with temperature ranging from 28.3°C to 29.7°C, current velocity from 0.039 m/s to 0.073 m/s, salinity from 29.3 ppt to 32 ppt, transparency from 1.9 m to 2.3 m, and ph from 7.3 to 7.4. Nitrate concentrations ranged from 0.042 mg/L to 0.076 mg/L, while phosphate concentrations ranged from 0.046 mg/L to 0.056 mg/L. The regression analysis revealed a moderate relationship between phytoplankton abundance and nutrient concentrations, with an R^2 value of 0.44. **Conclusions:** The study concludes that phytoplankton abundance in the Arungkeke Waters is influenced by nitrate and phosphate concentrations, with a moderate correlation observed. The presence of Bacillariophyceae and Dinophyceae classes indicates the ecological significance of these waters as a primary production area. **Novelty/Originality of this article:** This study provides valuable insights into the interaction between nutrient dynamics and phytoplankton abundance in the Arungkeke Waters, which is a relatively understudied area. By identifying the classes of phytoplankton present and quantifying their relationship with key nutrients, this research contributes to a better understanding of the ecological processes in coastal waters.

KEYWORDS: phytoplankton, nitrate, phosphate, oceanographic parameters.

1. Introduction

Plankton are organisms that live as animals or plants that float in water and follow the movement of currents and play an important role in supporting life in the waters (Reynolds & Padisák, 2013; Falkowski, 2012). Plankton are organisms that live as animals or plants that float in water and follow the movement of currents and play an important role in supporting life in the waters (Burhanuddin, 2019). There are several classes of plankton that are active swimmers, although plankton are still swayed by ocean currents (Hutabarat

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& Evans, 2014). Plankton are different from nekton, which are also pelagic organisms, but can swim strongly enough to resist the movement of the water mass. In contrast to Benthos (bottom animals) that live in the benthic region (bottom of the ocean), nekton and plankton live in the epipelagic region or commonly referred to as the photic zone, which is an area of water that gets a supply of sunlight (Delisa, 2012). Plankton consists of phytoplankton and zooplankton (Dewanti et al., 2018). Phytoplankton are plant-based microorganisms that live floating in water, relatively have no mobility, so that their existence is influenced by water movement and are able to photosynthesize. Phytoplankton is one of the biological parameters in waters that can be used as an indicator to evaluate the quality and fertility of waters, phytoplankton can also be said to be the largest contributor to oxygen because of the role of phytoplankton as an initial binder of solar energy (Iswanto et al., 2015). The existence of phytoplankton is very influential on life in the waters because phytoplankton plays an important role, namely as food for various organisms in the waters. In a high phytoplankton food chain will have the potential for large marine biological resources (Sundari, 2016). There are several kinds of phytoplankton that include a variety of sizes and shapes (D'Costa & Naik, 2019).

Phytoplankton is a plant that plays a very important role in aquatic ecosystems, because this group with chlorophyll content is able to carry out photosistesis (Peng et al., 2022; Naselli-Flores & Padisák, 2022; Gui & Sun, 2024). The process of photosynthesis in aquatic ecosystems carried out by phytoplankton (producers) is the main source of nutrients for other groups of aquatic organisms that act as consumers, starting with zooplankton and followed by other groups of aquatic organisms that form the food chain (Burhanuddin, 2019). Phytoplankton as primary producers play an important role in the food chain in a water body. The presence of phytoplankton is strongly influenced by the condition of physical and chemical parameters of waters, including nutrients (nitrates and phosphates), salinity temperature and others. That nutrients affect the abundance of phytoplankton populations. Furthermore, research by Yuliana et al. (2012) also stated that the composition and abundance of phytoplankton in a water body is highly dependent on the availability of nutrients. This is also in line with Radiarta (2013) which states that the abundance and distribution of phytoplankton have a strong enough relationship with temperature, brightness, salinity, current speed, nitrate and phosphate in the waters. Phosphate is one of the nutrients for protein formation and cell metabolism of organisms. In waters, phosphate compounds in the form of organic and inorganic phosphate can only be absorbed by vegetable organisms such as phytoplankton (Fajar et al., 2016).

The presence and abundance of phytoplankton is closely related to the condition of the physical - chemical parameters of the waters (El Gammal et al., 2017; Lim et al., 2025; Zhang et al., 2025; O'Boyle & Silke, 2010; Herawati et al., 2021). These conditions can affect the distribution of phytoplankton, especially the intensity of light and nutrients (nitrate and phosphate), differences in these conditions directly cause the distribution of phytoplankton differently. Nitrate and phosphate are one of the nutrients needed in the growth and development of phytoplankton. These two nutrients are needed in the growth of tissue cells of living marine organisms and also the process of photosistesis by phytoplankton. Phytoplankton is one of the biological parameters that is closely related to these nutrients. The high and low abundance of phytoplankton depends on the abundance of nutrients in the water (Paiki & Kalor, 2017). According to Ferianita et al. (2005) that phosphate and nitrate are very important for the growth and metabolism of phytoplankton which is an indicator to evaluate the quality and fertility of waters.

Arungkeke waters are one of the waters in Jeneponto district. These waters have shrimp ponds that produce organic waste. One of the contributors to nitrate and phosphate nutrients in Arungkeke waters is the disposal of shrimp pond waste. This pond waste contains a lot of organic matter derived from the rest of the feed given to the species cultivated in the pond. Therefore, a study was conducted to determine the relationship between nutrient content (nitrate and phosphate) with phytoplankton abundance in Arungkeke Waters, Jenepont Regency (Fachrul, 2005). The purpose of this study was to analyze the relationship between nitrate and phosphate nutrient content with phytoplankton abundance in Arungkeke Waters, Jeneponto Regency. The purpose of this study is to analyze the relationship between nitrate and phosphate nutrients with phytoplankton abundance in Arungkeke waters, Jeneponto regency.

2. Methods

2.1 Time, place, and materials

This research was conducted from March to May 2021. The data collection location was carried out in the Arungkeke water area, Jeneponto Regency. Water sample analysis and plant identification were conducted at the Chemical Oceanography Laboratory, Department of Marine Science, Faculty of Marine Science and Fisheries, Hasanuddin University, Makassar. Palajau Village is located in the administrative area of Arungkeke Sub-district, Jeneponto Regency, which borders the Flores Sea to the east. The village has abundant natural resource potential, especially in the fisheries and marine sectors.

The geographical boundaries of Palajau Village are Arungkeke Village to the north, Bulo-Bulo Village to the south, and Kalumpang Loe Village to the west. This geographical potential provides opportunities for the surrounding community to utilize the available water resources to improve their economy. Most people in Palajau Village depend on marine and aquatic products for their livelihoods, with the main professions being fishermen, shrimp farmers and seaweed farmers. Shrimp farming, especially super-intensive farming, is one of the most developed sectors in the region. In addition to providing positive impacts in the form of increased community income, this activity also brings great challenges to the environment, one of which is pond waste that can pollute surrounding waters. The tools and materials used in this study can be seen in Table 1.

Table 1. Tools used in the study.

Tools	Usability
Stationery writing	To record data in the field and in laboratory
Sample bottle	Filtered water sample holder
Identification book	Identification guidelines
Cool box	Storage of samples taken in the field
Erlenmeyer	Sample holder in the sample analysis process
10 L Bucket	Taking water samples
GPS	Station positioning
Measuring cup	To measure the solution to be used
Handrefractometer	Measuring salinity
MotorboatSSs	Means of transportation for sampling
Compass	Direction determination
Camera	Documentation tools
Current Kite	Measuring current
Microscope and Glass Object	Phytoplankton identification
pH meter	To filter out plankton
Dropper pipette	Measuring pH
Tube rack	Observed sampling
Sechi disk	Test tube holder
Sedgewick rafter	Measuring brightness
Spectrophotometer	Where to count phytoplankton
Stopwatch	Measuring nitrate and phosphate content
Thermometer	Measuring temperature
Test tube	As a sample site

The table provides an overview of the materials used in this study, highlighting their specific functions in the experimental process. The research primarily utilized seawater as the sample, along with various chemical reagents such as sulfuric acid, boric acid, and ammonium molybdate, which served as phosphate and nitrate reagent solutions. Additional materials, including indicators like 2% amylum and Brucine solution, were employed to facilitate color changes and determine nitrate concentrations. Cleaning agents and filtration materials, such as aquades, tissue, and Whatman Paper No. 42, were also incorporated to ensure the accuracy and reliability of the analysis. Material in this study can be seen in Table 2.

Table 2. Materials used in the study.

No.	Material	Usability
1.	Sea Water	Research sample
2.	Sulfuric Acid (H_2SO_4)	As a phosphate reagent solution
3.	Concentrated Sulfuric Acid	As a nitrate reagent solution
4.	Boric Acid (H_3BO_3)	As a phosphate indicator solution
5.	Ammonium molybdate	As a phosphate reagent solution
6.	Sulfanilic acid	As a nitrate reagent solution
7.	Aquades and Tissue	Cleaning and sterilizing tools
8.	Whatman Paper No. 42	To screen the sample
9.	2% Amylum Indicator	To change the color of the solution from light yellow into blue
10.	Lugol's solution	Sample preservative
11.	Brucine solution	Determination of nitrate concentration
12.	Sodium Thio Sulfate Solution	For the titration liquid to turn clear

2.2 Research procedures and data analysis

As the initial stage of this activity, several preliminary activities were carried out, including field observations and literature studies. Field observations were intended to identify problems as the basis for research planning. Furthermore, a literature study was conducted to strengthen the theoretical framework, formulation of research problems, search for literature related to the object of study and the preparation of a research methodology framework. Determination of the station point is near the outlet of pond. the number of station points as many as one station with a repeat of three times, sampling is done every three starting from 06:00, 09:00, 12:00, 15:00 and 18:00 WITA. Taking point coordinates using GPS (Global Positioning System) on each replicate.

Phytoplankton sampling was carried out at a predetermined station. At the station, sampling was carried out 3 times. Phytoplankton sampling is done by taking seawater samples using a bucket with a volume of 10 liters 10 times, so that the volume of filtered water is 100 liters by filtering using plankton net No. 25. Water samples collected in the plankton net bucket are transferred to a 100 ml sample bottle and add 1% lugol solution as much as 2 ml to maintain the shape and color of phytoplankton. At the station, salinity, temperature, pH, and current parameters were measured directly and water samples were also taken for further measurements in the laboratory which included Nitra (NO_3), Phosphate (PO_4), and phytoplankton.The identification of phytoplankton samples was carried out using a microscope and SRC Cell, namely by homogenizing the sample first, taking phytoplankton samples as much as 1 ml using a drop pipette, inserting into the SRC Cell then closing the SRC Cell with a cover glass, placing the SRC Cell on the microscope preparation table using magnification 10, adjusting the light and focus on the microscope and then identifying the phytoplankton genus, counting the number of individuals obtained and recording the observations. Brightness measurements were taken using a Secchi disc. The Secchi disc is inserted into the water so that the black and white colors on the secchidisk are not visible and the length of the rope is recorded (D1), then the Secchi disc is lifted slowly to the surface until the black and white colors are visible and the length of the rope is recorded (D2).

Temperature measurements were made by inserting a thermometer into the water for a few minutes then reading the numbers on the thermometer and recording the results. Salinity measurements were made using a hand refractometer. Before use, the hand refractometer is calibrated first by dripping distilled water on the prism then drying it with a tissue. Next, drip the seawater sample on the prism and then point the hand refractometer towards the light and read the value indicated on the scale. The degree of acidity (pH) was measured using a pH meter. Before use, the pH meter is first calibrated using distilled water, then dip it into a container containing water samples, then record the pH value indicated on the pH meter display. Measurement of current speed and direction is carried out using a current kite and compass. The measurement method is to release the current kite in the water and let it drift as far as 10 m. The time of releasing the current kite into the water until the rope stretches as far as 10 m is calculated using a stopwatch. Furthermore, the direction of the current is determined by using a compass.

The determination of nitrate levels is carried out using the Bruchine method, nitrate measurements are carried out using a DREL 2800 spectrophotometer, by filtering 25-50 ml of sample water using Whatman filter paper no 42 then taking 5 ml of sample water that has been filtered using a dropper and then putting it in a test tube, adding 0.5 ml of Bruchine solution and then let stand for about 2-4 minutes, adding 5 ml of concentrated sulfuric acid and then letting the solution cool down after that measuring nitrate levels with a wavelength of 410 nm. The determination of phosphate levels used the stannous chloride method, in measuring phosphate levels is carried out using a DREL 2800 spectrophotometer, by filtering 25-50 ml of water samples with Whatman filter no.42 then taking 2 ml of filtered water samples and then putting them into a test tube. Add 3 ml of phosphate oxidizing solution, a mixture of 2.5 sulfuric acid, ascorbic acid and ammonium molybdate then shake then add 2 ml of 2% boric acid then shake, leave for about 30 minutes then measure the phosphate content with a wavelength of 660 nm. The data analysis used in this study is multiple regression analysis. The interpretation of the coefficient of determination R value uses the following table (Sugiyono, 2007). Interpretation of the coefficient of determination R can be seen in Table 3.

Table 3. Interpretation of the coefficient of determination R

Coefficient interval	Relationship level
0.00 – 0.199	Very Low
0.20 – 0.399	Low
0.40 – 0.599	Medium
0.60 – 0.799	Strong
0.80 – 1.000	Very Strong

The table presents the interpretation of the coefficient of determination (R), which is a key statistical measure used in multiple regression analysis to assess the strength of the relationship between independent and dependent variables. According to Sugiyono (2007), the coefficient R is categorized into five levels: very low (0.00 – 0.199), low (0.20 – 0.399), medium (0.40 – 0.599), strong (0.60 – 0.799), and very strong (0.80 – 1.000). This classification helps in determining the extent to which the independent variables explain the variability of the dependent variable, providing valuable insights into the predictive power of the regression model.

3. Results and Discussion

3.1 Site overview

Palajau Village is located in the administrative area of Arungkeke Sub-district, Jeneponto Regency, which borders the Flores Sea to the east. The village has abundant natural resource potential, especially in the fisheries and marine sectors. The geographical boundaries of Palajau Village are Arungkeke Village to the north, Bulo-Bulo Village to the south, and Kalumpang Loe Village to the west. This geographical potential provides opportunities for the surrounding community to utilize the available water resources to improve their economy. Most people in Palajau Village depend on marine and aquatic products for their livelihoods, with the main professions being fishermen, shrimp farmers and seaweed farmers. Shrimp farming, especially super-intensive farming, is one of the most developed sectors in the region. In addition to providing positive impacts in the form of increased community income, this activity also brings great challenges to the environment, one of which is pond waste that can pollute surrounding waters.

Wastes generated from super-intensive pond activities contain various organic and inorganic substances that can affect water quality in the waters of Palajau Village. The accumulation of waste has the potential to disrupt the balance of aquatic ecosystems, including the abundance of phytoplankton as primary producers in the aquatic environment. Phytoplankton have an important role in the food chain because they are the main source of energy for other organisms (Fachrul, 2007). The abundance and composition of phytoplankton are strongly influenced by the condition of physical and chemical parameters of the waters, such as temperature, salinity, brightness, and nutrient concentrations such as nitrate and phosphate. Environmental conditions influenced by community activities on the coast need to be a serious concern. Continuous monitoring and management of shrimp pond effluent is essential to maintain the quality of aquatic ecosystems. Therefore, this study not only aims to analyze the relationship between nitrate and phosphate content with phytoplankton abundance, but also to provide an overview of the condition of Palajau Village waters as a first step in better management of the coastal environment. By understanding this relationship, it is hoped that the management of ponds and coastal community activities can be carried out sustainably without compromising the balance of existing ecosystems.

3.2 Oceanographic parameters of the waters

Based on the observation of physical and chemical oceanographic parameters in Arungkeke Waters, the highest temperature value is 29.7°C at 12.00 while the lowest value is 28.3°C at 06.00 and 18.00. The highest salinity value was 32 ppt at 09.00 while the lowest value was 29.3 ppt at 18.00. The highest current velocity value was 0.075 m/sec at 15:00 while the lowest was 0.039 m/sec at 06:00 and 09:00. The highest brightness value was 2.3 m at 12:00 while the lowest value was 1.9 m at 06:00 and 15:00. The highest pH value was 7.4 at 15.00 and 18.00 while the lowest was 7.3 at 06.00, 09.00 and 12.00. The highest nitrate value was 0.76 mg/L at 18:00 while the lowest value was 0.042 mg/L at 12:00. The highest phosphate value was 0.056 mg/L at 15:00 while the lowest value was 0.046 mg/L at 12:00. The measurement results of various physical and chemical oceanographic parameters at the research site can be seen in Table 4.

Table 4. Oceanographic parameter measurement results

No.	Parameters	Time				
		06.00	09.00	12.00	15.00	18.00
1	Temperature (°C)	28.3	29	29.7	28.7	28.3
2	Salinity (ppt)	30.3	32	31.7	29.7	29.3
3	Current Velocity (m/sec)	0.039	0.039	0.073	0.075	0.073
4	Brightness (m)	1.9	2.2	2.3	1.9	2.0
5	pH	7.3	7.3	7.3	7.4	7.4
6	Nitrate (mg/L)	0.048	0.052	0.042	0.055	0.076
7	Phosphate (mg/L)	0.051	0.049	0.046	0.056	0.049

Temperature is one of the factors that can affect the process of photosistesis in phytoplankton. Based on the results of the study, the average temperature range obtained at each measurement time is 28°C-30°C. The highest temperature obtained was 29.7°C at 12:00, while the lowest temperature obtained was 28.3°C at 06:00 and 18:00. High sea surface temperatures are caused by solar radiation, according to (Nonji, 2005) water temperatures at the surface are influenced by meteorological conditions. Meteorological factors that play a role here are rainfall, evaporation, air humidity, air temperature, wind speed and solar radiation intensity. Therefore, surface temperatures usually follow a seasonal pattern. The temperature obtained shows that phytoplankton can still tolerate the temperature of the waters at the research site. That the temperature range of 28°C-32°C is a fairly stable range and is still within the limits of feasibility for plankton life. The direct effect of temperature on plankton is to increase chemical reactions so that the rate of photosynthesis increases with increasing temperature. The optimum temperature for plankton growth ranges from 25°C-32°C.

Salinity or salt content is one of the parameters that is very important for the life of organisms in the sea, especially plankton (Prasetyaningtyas et al., 2012). Based on the results of the study, the range of salinity values obtained at each measurement time is 29-32 ppt. The highest salinity obtained was 32 ppt at 09.00, while the lowest salinity obtained was 29.3 ppt at 18.00. An increase or decrease in salinity can affect plankton abundance (Damar et al., 2012). The salinity value obtained is still in a good range for phytoplankton growth. The optimum salinity range for phytoplankton life is 28-34 ppt. Seawater plankton can tolerate salinity levels greater than 20 ppt.

Current is a flowing movement of a mass of water that is not periodic, caused by external forces, including wind pressure friction or by differences in water density or by long wave motion. The current will change due to atmospheric pressure, horizontal density gradient caused by differences in heating or due to diffusion of dissolved materials from sediments and water flow. According to Faturohman et al. (2016) mentioned that the current is the main factor that limits the spread of biota in the waters. The current speed is not large at the surface of the water, high enough brightness, and moderate nutrient content can encourage high abundance of plankton in a body of water (Widianingsih, 2007). Based on the results of the study, the range of current velocity values obtained is 0.039-0.075 m/s. The slowest current velocity value obtained was 0.039 m/s at 06.00, while the fastest current velocity value obtained was 0.075 m/s at 15.00. The range of current velocities obtained is included in the very slow category. Based on the current speed of the waters are grouped into five groups, namely: Very fast current (>1 m/s), fast current (0.5-1 m/s), moderate current (0.25-0.5 m/s), slow current (0.1 - 0.25 m/s) and very slow current (<0.1 m/s).

Water brightness is the ability of light to penetrate the water layer at a certain depth. Light is one of the most important factors for phytoplankton organisms because without light phytoplankton cannot carry out photosistesis (Khaqiqoh et al., 2014). The low value of water brightness can be caused by the presence of suspended and dissolved organic and inorganic materials. Based on the results of the study, the range of brightness values obtained is 1.9-2.3 m. The highest brightness value obtained was 2.3 m at 12:00, while the lowest brightness value obtained was 1.9 m at 06:00 and 15:00. The low brightness value at 06.00 is due to the low light intensity and at 15.00 is due to cloudy weather conditions at the time of sampling. This is in accordance with the statement (Effendi, 2003) that factors that can affect brightness are weather conditions, measurement time, turbidity, suspended solids and accuracy when taking measurements.

The degree of acidity (pH) of a water body is one of the chemical parameters that is quite important in monitoring water quality. Based on the results of the study, the range of pH values obtained was 7.3-7.4. The highest pH value obtained was 7.4 at 15.00 and 18.00, while the lowest pH value was 7.3 at 06.00, 09.00 and 12.00. Syamsuddin (2014) stated that the pH value of seawater can be influenced by several factors, one of which is the entry of waste into the waters. The range of pH values obtained during measurement is still suitable for plankton growth. The pH is still suitable for the life of aquatic organisms between 6.6-8.5. This is also reinforced by the statement (Effendi, 2003) that most aquatic biota are sensitive to changes in pH and like pH values around 7-8.5. Based on (KEPMEN LH No. 51, 2004) regarding seawater quality standards for marine biota such as plankton, that the pH of good waters ranges from 7-8.5.

Nitrate is one of the nutrients most needed by living things, especially plants to carry out the process of photosynthesis. Phytoplankton as primary producers in the food chain in waters really need nitrate to carry out the process of photosynthesis in order to produce oxygen. Based on the results of the study, the range of nitrate values obtained is 0.042-0.076. The highest nitrate value is 0.076 at 18.00. while the lowest nitrate value is 0.042 at 15.00. According to (Effendi, 2003), oligotrophic waters have nitrate levels between 0-1 mg/L, mesotrophic waters have nitrate levels between 1-5 mg/L and europhic waters have nitrate levels ranging from 5-50 mg/L. The nitrate content indicates that Arungkeke waters are categorized as oligotrophic waters or waters with low fertility. However, it can still support phytoplankton growth even though it is not optimal. The optimum growth of phytoplankton requires nitrate levels in the range of 0.9-3.5 mg/L. From the range of values it can also be explained that the nitrate concentration has not exceeded the limit that can trigger phytoplankton to bloom, which is 0.2 mg/L, which can trigger nutrient enrichment or eutrophication which in turn triggers an explosion of algae populations, especially phytoplankton and aquatic plants rapidly (blooming).

Phosphate is one of the nutrients needed by phytoplankton to carry out the process of photosynthesis. The high and low levels of phosphate in the water can be used as a determinant of the level of water fertility. Based on the results of the study, the average range of phosphate concentration obtained was 0.046-0.056 mg/L. The phosphate content indicates that Arungkeke waters are included in the category of waters with moderate fertility. According to (Effendi, 2003) that waters that have moderate fertility have total phosphate levels ranging from 0.021-0.5 mg/L. The optimum phosphate concentration for phytoplankton growth ranges from 0.09-1.80 mg/L. Furthermore (Effendi, 2003) states that phosphate concentrations around 0.02 are dominated by Bacillariophyceae (diatoms).

3.3 Phytoplankton composition

From the observation results, it shows that the Bacillariophyceae class has the highest abundance at each sampling time (Figure 1). The high abundance of the Bacillariophyceae class is because the class is widespread in all aquatic environments and its presence is more dominant in estuarine waters to the sea. Ramadani (2012) stated that the high abundance of phytoplankton from the Bacillariophyceae class is due to phytoplankton belonging to this class being widespread in estuarine waters to the sea and its more dominant presence in a body of water.

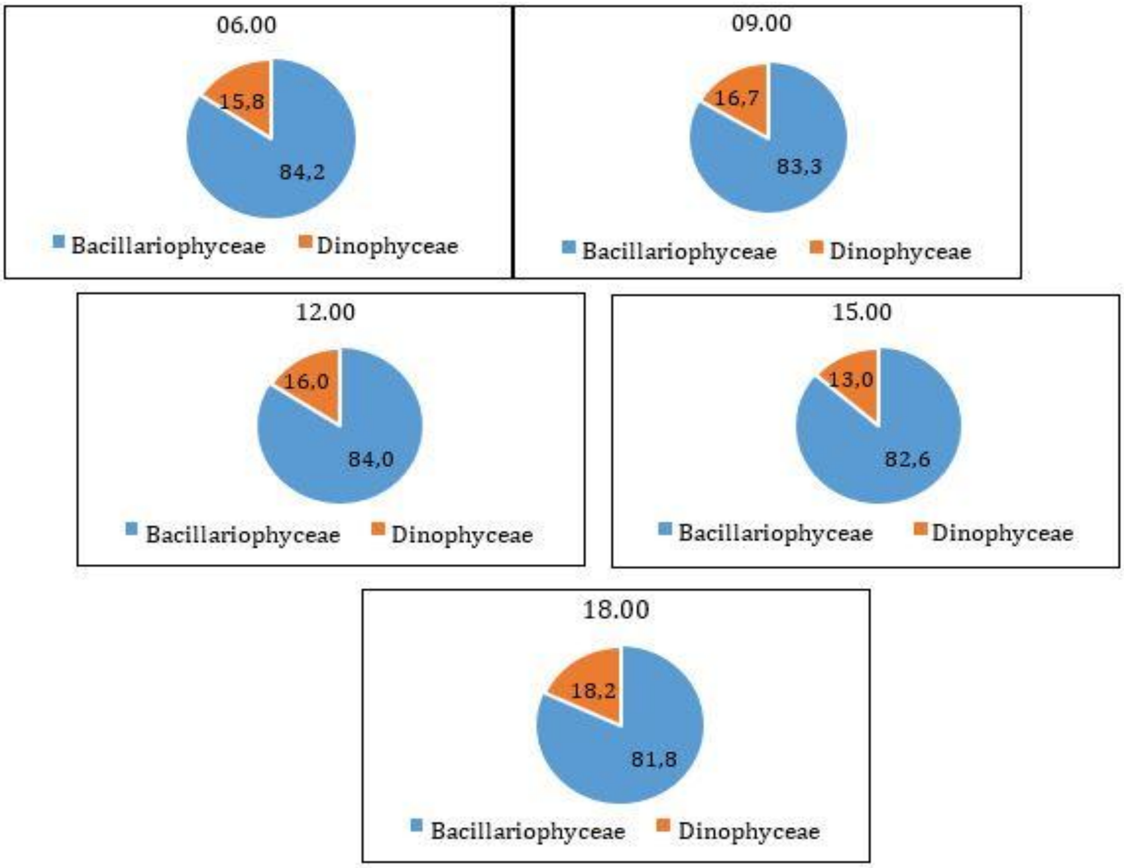

Fig. 1. Percentage results of phytoplankton classes

The results showed that the highest genus composition was at jaM 12.00 with a total of 25 genus consisting of Bacillariophyceae and Dinophyceae classes or with a percentage value of 84.0% and 16.0%. While the lowest phytoplankton composition was at 06.00 with a total of 19 genus consisting of *Bacillariophyceae* and *Dinophyceae* classes or with a percentage value of 84.2% and 15.8%. The phytoplankton genus that often appears with a considerable amount is Rhizosolenia and *Chaetoceros*. The results of phytoplankton species composition can be seen in Table 5.

Table 5. Phytoplankton speciess composition

No	Phytoplankton genus	Hours														
		06.00			09.00			12.00			15.00			18.00		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Class Bacillariophyceae																
1	Rhizosolenia	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2	Thalassionema	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3	Chaetoceros	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4	Cerautaulina	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
5	Triceratium	-	-	-	-	-	*	*	*	*	*	*	*	-	-	-
6	Cylindrotheca	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
7	Hemidiscus	-	-	-	-	-	*	-	*	*	-	-	*	-	-	*
8	Coscinodisces	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
9	Asterionelloposis	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
10	Navicula	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
11	Odontella	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
12	Eucampia	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13	Thallasiosira	-	*	*	*	*	*	*	*	*	*	*	*	-	*	*
14	Guinardia	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
15	Ditylum	-	-	-	-	*	-	-	*	-	-	-	-	-	-	-
16	Pleurosigma	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
17	Thallasiothrix	*	*	*	*	*	*	*	*	*	*	*	*	*	-	*
18	Oscillatoria	-	*	-	*	*	*	*	*	*	*	*	*	*	*	*
19	Bacteriastrum	-	-	-	-	*	*	*	*	*	*	*	*	-	-	-
20	synedra	-	-	-	*	*	*	*	-	*	-	-	-	-	-	-
21	Lauderia	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Class Dinophyceae																
22	Ceratium	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
23	Pyrocystis	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
24	Protoperidium	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
25	Dinophysis	-	-	-	*	*	*	*	*	*	*	*	*	*	*	*

Description: * = found; -= not found

Based on the results of the percentage enumeration of phytoplankton classes at each sampling time, it shows that the Bacillariophyceae class has a higher composition value than the Dinophyceae class at each sampling time. The Rhizosolenia genus has a very high number and frequency of occurrence presumably because the genus is one of the genus of the Bacillariophyceae class that is commonly found in the sea and is resistant to changing environmental conditions. The type of phytoplankton from the Bacillariophyceae class is a common type found at sea even in changing weather conditions. The genus of Bacillariophyceae is able to grow and develop quickly even though the waters have low nutrient conditions and brightness levels. This is also because this genus can regenerate and reproduce greater and also has the ability to adapt well. That the class of Bacillariphyceae is generally found in tropical waters. The percentage results can be seen in Figure 1. The figure illustrates the composition of Bacillariophyceae and Dinophyceae at different time intervals throughout the day. The data are represented in pie charts, showing the percentage of each phytoplankton group at 06:00, 09:00, 12:00, 15:00, and 18:00. *Bacillariophyceae* (blue) consistently dominates the composition, ranging between 81.8% and 84.2%, while Dinophyceae (orange) accounts for a smaller proportion, fluctuating between 13.0% and 18.2%. The slight variations in the percentages suggest potential diurnal changes in the relative abundance of these phytoplankton groups, possibly influenced by environmental factors such as light availability, temperature, or nutrient dynamics.

3.4 Phytoplankton abundance

Based on the observations that have been made, it shows that the Bacillariophyceae class has the highest abundance at each sampling time (Figure 3). The results of phytoplankton abundance values obtained at 06.00 hours, namely from, the Bacillariophyceae class was 394 cells/L while the *Dinophyceae* class was 24 cells/L, the phytoplankton abundance value at 09.00 hours was 752 cells/L from Bacillariophyceae and 48 cells/L from Dinophyceae. The phytoplankton abundance value at 12:00 am was 778 cells/L of Bacillariophyceae and 52 cells/L of *Dinophyceae*.

The phytoplankton abundance value at 15:00 is 430 cells/L of Bacillariophyceae and 27 cells/L of Dinophyceae. The result of the abundance value at 18.00 is 262 cells/L of Bacillariophyceae and 16 cells/L of Dinophyceae. The high and low value of phytoplankton abundance can be influenced by the brightness of the waters where the highest phytoplankton abundance value is at 12.00 with the highest brightness value and the lowest phytoplankton abundance value is at 18.00 with the second lowest value of the sampling time.

The high abundance of phytoplankton at 12:00 is due to the high brightness value that allows sunlight to penetrate the water well so that phytoplankton can photosynthesize well. According to (Facta et al., 2006) in the presence of sunlight, phytoplankton actively photosynthesize while absorbing nutrients such as nitrates, phosphates and releasing oxygen. The high abundance of the Bacillariophyceae class is because this class is widespread in marine waters and easily adapts to the environment.

The abundance of the Bacillariophyceae class in a body of water is due to the phytoplankton of this class having properties that are easily adaptable to the environment. The resistant to extreme conditions and have a high reproductive power that can double in 18-36 hours compared to other classes. Based on the observation data, there are several genus of phytoplankton from the *Bacillariophyceae* class that have a considerable amount. The phytoplankton genus that often appears and has a large number at each sampling time is Rhizosolenia. Average value of phytoplankton abundace can be seen in Figure 3.

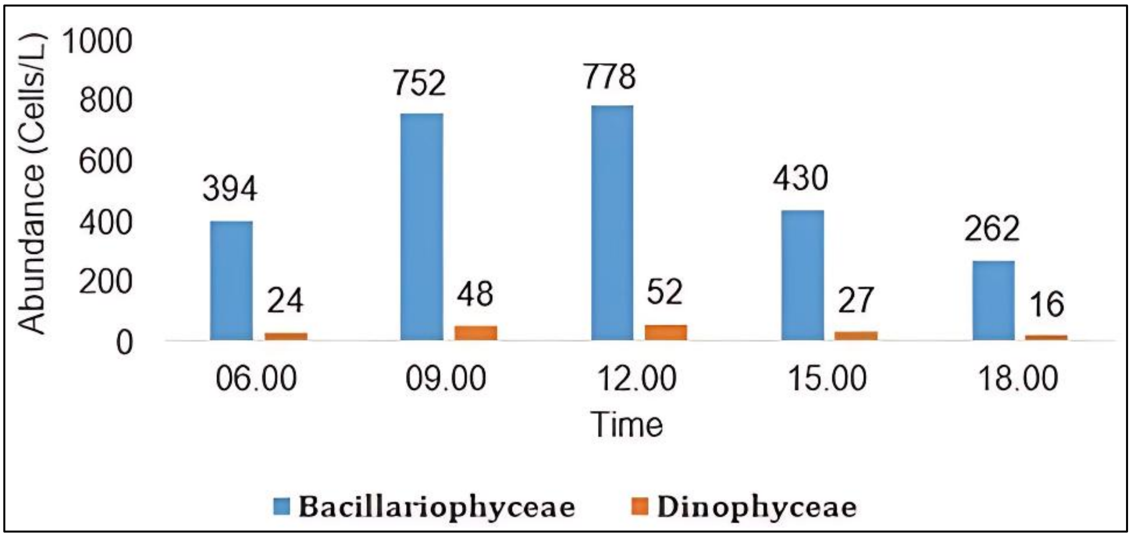

Fig. 2. Average value of phytoplankton abundance (cells/L)

3.5 Relationship of nutrient nutrients to phytoplankton abundance

Based on the graph of the relationship between nutrient content (nitrate and phosphate) with phytoplankton abundance shows that the higher the abundance of phytoplankton, the nutrient content (nitrate) decreases and vice versa. Based on the regression analysis conducted to see the relationship between nutrient content (nitrate and phosphate) to phytoplankton abundance, the value of R2 (regression coefficient) is 0.44 with the regression equation Y = 1504 - 8458.3 x NO3 - 9708.1 x PO4 which means it shows a moderate relationship. The pattern of the relationship between phytoplankton abundance and nutrients shows a negative relationship, which means that the higher the abundance of phytoplankton, the lower the nutrient content. The graph of the relationship between phytoplankton abundance and nutrients can be seen in Figure 4.

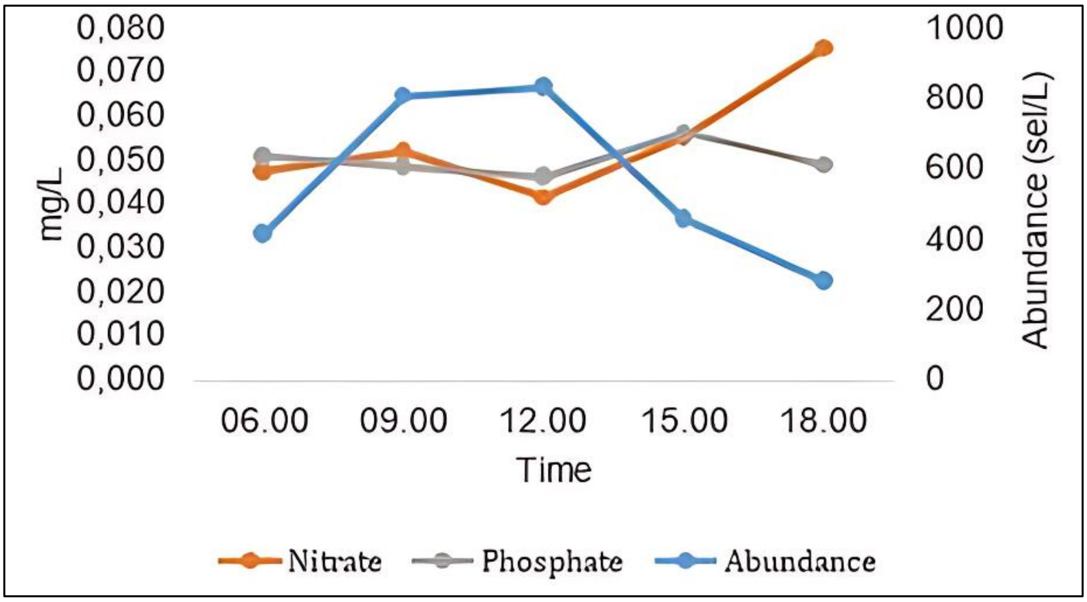

Fig. 3. Graph of the relationship between phytoplankton abundance and nutrients.

Based on the results of the regression analysis, the R^2 value (regression coefficient) was obtained <0.5, indicating a moderate relationship with a negative relationship pattern. This negative relationship is caused by nutrient utilization following light intensity. During the day, especially at 12:00pm, high light intensity causes phytoplankton to photosynthesize more actively and simultaneously absorb nutrients. In contrast, in the morning and evening, the light intensity is lower so that nutrient levels in the water become higher. According to Facta et al. (2006), phytoplankton photosynthetic activity is strongly influenced by chloroplasts that absorb the intensity of light that hits them. When light is available in sufficient quantities, phytoplankton can maximize the photosynthetic process and absorb nutrients such as nitrate, sulfate, and phosphate, while releasing oxygen into the water. This process shows that the presence of light is very important in regulating phytoplankton productivity in a water body.

The main nutrients required by phytoplankton to grow and reproduce are nitrate and phosphate. These two elements are considered as limiting factors in phytoplankton productivity. Nitrate and phosphate play an important role in providing energy and structural material for phytoplankton cells. When the concentrations of these two nutrients are sufficient, phytoplankton growth and reproduction can take place optimally, thus having a direct impact on primary productivity in these waters. On the other hand, high concentrations of nitrate and phosphate that are not optimally utilized by phytoplankton can lead to eutrophication, especially if human activities in the surrounding waters, such as pond activities, produce nutrient-rich effluents. This can have a negative impact on water quality and the balance of aquatic ecosystems. Therefore, nutrient management in waters must be done carefully to support phytoplankton productivity without causing adverse environmental impacts. The relationship patterns found in this study provide important information about the interactions between light, nutrients and phytoplankton activity in water. This understanding can be used to sustainably manage the quality of aquatic environments, especially in anticipation of negative impacts from human activities that can affect nutrient levels and the overall aquatic ecosystem.

4. Conclusions

Based on the research conducted, it can be concluded that the composition and abundance of phytoplankton in the study site consist of two main classes, namely Bacillariophyceae and *Dynophyceae*. The presence of these two classes indicates that phytoplankton have an important role in aquatic ecosystems, especially in relation to nutrient cycling. The relationship between nutrients and phytoplankton is at a moderate level, where an increase in phytoplankton abundance significantly causes a decrease in nutrient levels in the water. The results of this study suggest that the activity of phytoplankton in absorbing nutrients can contribute to the balance of aquatic ecosystems. However, this also needs further attention in the context of aquaculture activities, as changes in nutrients due to phytoplankton activity can impact the ecosystem as a whole.

For future research, it is suggested that similar studies be conducted with a focus on other types of plankton, such as zooplankton, especially in areas around ponds. This study can provide a deeper insight into the interaction between zooplankton and aquatic ecosystems, and its impact on the sustainability of aquaculture activities. In addition, similar studies can be conducted in different locations to understand how aquaculture activities affect environmental conditions in different regions. This is important for the development of environmentally friendly and sustainable aquaculture management strategies.

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