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THE RELATIONSHIP BETWEEN NITRATE, PHOSPHATE AND ORGANIC MATERIAL CONCENTRATION TO PHYTOPLANKTON ABUNDANCE IN RUPAT ISLAND WATERS

Doli Juni Setia Tanjung[1]*, Bintal Amin[1], Mubarak[1]
[1]Department of Marine Science, Faculty of Fisheries and Marine, Universitas Riau
Kampus Bina Widya KM. 12,5, Simpang Baru, Bina Widya, Pekanbaru, Riau 28293
*dolijunisetiatanjung@gmail.com

ABSTRACT

Over time, Rupat Island has experienced very rapid development, marked by various activities such as plantations, agriculture, farming, and ecotourism activities which are growing rapidly. This study aims to determine the relationship between concentrations of nitrate, phosphate, and organic matter on the abundance of phytoplankton in Rupat Island waters. The results showed that the average nitrate concentration was relatively high, ranging from 0.0993-0.1618 mg/L and the average phosphate concentration was around 0.0951-0.1571 mg/L. Furthermore, the concentration of organic matter in water ranged from 27.555-35.234 mg/L. The lowest abundance of phytoplankton was found in the Station II area with an average abundance value of around 416.67 cells/L, while the highest average abundance was in the Station V area with an average value of 993.05 cells/L. The relationship between the content of nitrate, phosphate, and organic matter with the abundance of phytoplankton in the Rupat Island area was insignificant or weak with a coefficient of determination (R^2) of 8%, 10.5% and 3.3%.

Keywords: Nitrate, Phosphate, Organic Matter, Phytoplankton, Rupat Island.

1. INTRODUCTION

Over time, Rupat Island has experienced very rapid development coupled with the condition of Rupat Island which is directly opposite the waters of the Strait of Malacca and the Rupat Strait which are dense waters with various activities. This is evidenced by the development of activities in the area such as oil palm, head, and rubber plantations. In addition, Rupat Island also has aquaculture, tourism activities, and agricultural activities.

The high level of activity has a negative impact that puts pressure and impacts on aquatic ecosystems. Amin et al.[1] stated that local hydrodynamics and coastal topography, especially the current direction in Rupat Strait may play an important role in carrying contaminated water. Excess nitrogen content from plantation activities, agriculture, and fisheries activities causes eutrophication. Meirinawati & Muchtar[2] stated that the presence of nitrogen from industrial and domestic waste, when in water bodies in high concentrations can cause eutrophication.

The presence of plankton living in the water column is a bio-indicator of water quality; plankton can represent the state of water quality in zones that are fish habitat in general. Plankton consists of two groups, namely phytoplankton which are plant plankton, and zooplankton which are animals. The presence of phytoplankton from the Bacillariophyceae class is also used as a bio-indicator to evaluate water quality and fertility levels due to its short life cycle and sensitivity to changes in aquatic environmental conditions[3]. So if eutrophication or pollution occurs due to human activities both on land and at sea, it

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will affect the productivity of waters in the area. This study aims to determine the relationship between the concentrations of nitrate, phosphate, and organic material to phytoplankton abundance in Rupat Island Waters

2. RESEARCH METHOD

Time and Place

The research time was in September 2022. The research location consisted of 6 research stations consisting of 18 sampling points. Determination of sampling locations based on Purposive Sampling. The research location is Rupat Island Waters, which is located in Bengkalis Regency, Riau Province (Figure 1).

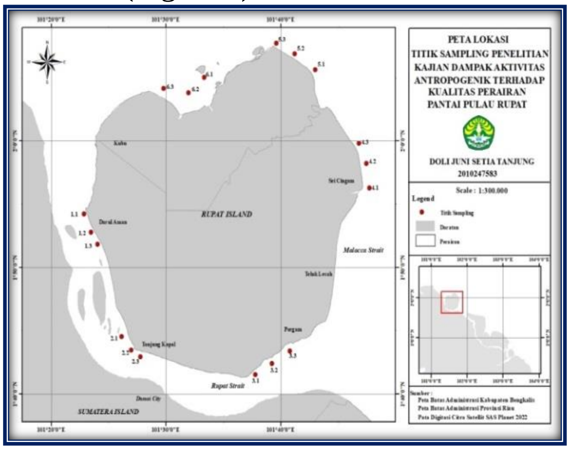

Figure 1. Research location

Determination of Sampling Stations

In this study, there are 6 stations. 3 stations are around the Rupat Strait area and 3 stations are in the Malacca Strait area. In one station there are 3 sampling points, the distance between sampling points is ±100 m. The distance between the coastline of Rupat Island and the sampling point at the research station is ±100 m from the shoreline.

Nitrate Concentration Analysis

Analysis of nitrate concentration was carried out by reading the absorbance value using an Ultraviolet Spectrophotometer with a wavelength of 220 nm and 275 nm, then continued with the calculation through the absorbance standard value curve. The principle of this method is that before calculating the nitrate content in a sample, it is necessary to first make a regression curve of the standard solution that has been made. After the absorbance value is obtained, a regression curve is made with the Excel program. The value obtained is in the form of an equation and the value of R^2, the equation can be used to find the concentration value of the nitrate sample.

Phosphate Concentration Analysis

Phosphate concentration analysis was carried out using an Ultraviolet Spectrophotometer. In this method, phosphate levels are read at a wavelength of 880 nm with a range of levels between 0.01-1 mg/l. The principle of this method is that in an acidic atmosphere, ammonium molybdate and potassium antimony tartrate react with orthophosphate to form a phosphomolybdic acid compound then reduced by ascorbic acid to a molybden blue complex.

Water Organic Matter Analysis

Analysis of total organic matter in water samples was carried out in the laboratory using the titrimetric method according to SNI 06-6989.22-2004. Then the value of total organic matter was calculated with the permanganate value with the following equation:

$$KMnO_4\left(\frac{mg}{L}\right)=\frac{[(10\text{-}a)b\text{-}(10 \times c)]1 \times 31{,}6 \times 1000}{d} \times f$$

Description:

a : Volume of 0.01 N $KMnO_4$ (Titration)
b : KMnO normality$_4$ (Actual)
c : Oxalic acid normality
d : Sample volume
f : The dilution factor of the test sample

Phytoplankton Abundance

Water samples were taken using a sample bottle and then preserved in a 4% formalin solution. Phytoplankton abundance is expressed quantitatively by the number of cells/L, phytoplankton abundance is calculated based on the APHA formula *in* Arbianti et al.[4]:

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

Description:

N : Phytoplankton abundance (ind/L)
X : Filtered sample water volume (125 mL)
Y : Volume of sample water under the 22 x 22 mm cover glass (0.06 mL)
V : Volume of filtered water (100 L)
Z : Number of individuals found (ind)

Relationship Analysis

To see the abundance of phytoplankton with the concentration of nitrate, phosphate, and organic matter content between stations, a simple linear regression test was performed using IBM SPSS Statistic 21 software*:*

$$Y=a+\beta x$$

Where:

Y : Dependent variable
a : Constanta
β : Regression coefficient
x : Independent variable

If the β value is positive (+), it shows a unidirectional relationship between the independent variable and the dependent variable. In other words, an increase or decrease in the amount of the independent variable will be followed by an increase or decrease in the amount of the dependent variable. Meanwhile, if the value of β is negative (-), it shows the opposite relationship between the independent variable and the related variable. In other words, any increase in the value of the independent variable will be followed by a decrease in the value of the dependent variable, and vice versa. Several assumptions must be met in the use of abundance functions to produce the best estimator so that a more accurate model is obtained. Some statistical tests that need to be done include the following. The value of R^2 can be calculated by the formula:

$$R^2=\frac{JKR}{JKT}$$

Description:

R^2 : Coefficient of Determination
JKR : The sum of squares of regression
JKT : Total sum of squares

3. RESULT AND DISCUSSION

Nitrate, Phosphate, and Organic Matter Concentration

The average nitrate concentration obtained in the Rupat Island area is relatively high ranging from 0.0993-0.1618 mg/L. The high concentration in the Rupat Island area is feared to cause eutrophication and endanger marine biota. Because it is almost close to the value of nitrate concentration experiencing eutrophication ranging more than 0.2 mg/L. More details can be seen in Figure 2.

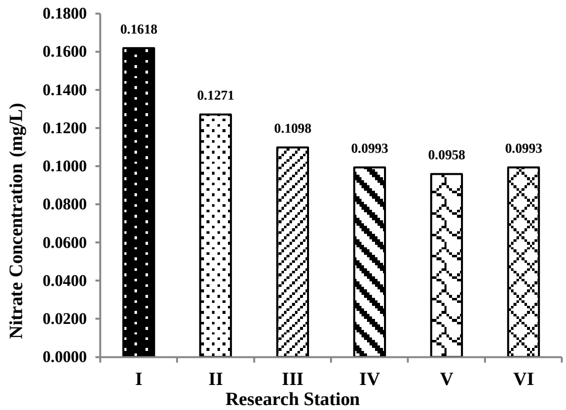

Figure 2. Average nitrate concentration

Effendi[5] stated that nitrate concentrations of more than 0.2 mg/L can cause eutrophication of waters and further stimulate the rapid growth of algae and aquatic plants (blooming).

The high nitrate concentration in Rupat Island waters can be expected to be caused by a high input of organic matter from land activities which can be in the form of land erosion, the input of household waste, plantation waste in the form of fertilizer residues, and aquaculture activities that are carried into marine waters. Furthermore, the average phosphate concentration ranges from 0.0951-0.1571 mg/L. More details can be seen in Figure 3.

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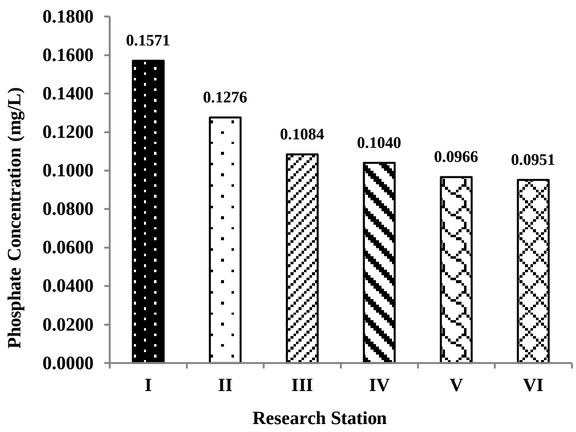

Figure 3. Average phosphate concentration

Station I has the highest phosphate concentration with an average of 0.1571 mg/L and the lowest concentration is at Station VI with an average of 0.0951 mg/l. This value indicates that the phosphate concentration is dangerous for the waters of the Rupat Island area which can lead to eutrophication. Subarijanti in Kadim et al.[6] stated that waters with phosphate values of more than 0.1 mg/L are eutrophication waters, where phytoplankton blooming often occurs.

However, phosphate is also needed for phytoplankton growth and metabolic processes. Phosphate is a nutrient needed for the growth and metabolism of phytoplankton and other marine organisms in determining the fertility of waters, its condition is unstable because it is easily subjected to the process of erosion, weathering, and dilution. The average value of organic matter concentration can be seen in Figure 4.

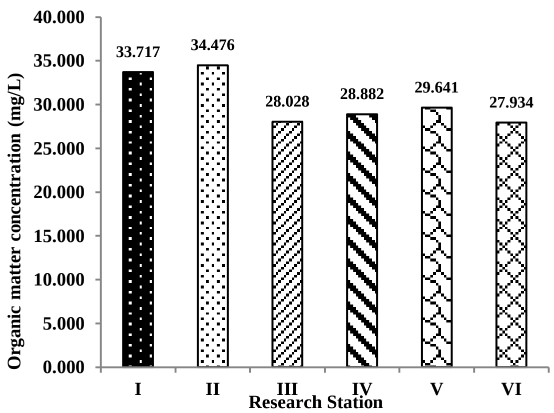

Figure 4. Average water organic matter concentration

Figure 4 illustrates the average water organic matter concentration ranging from 27.934-34.476 mg/l. The Station II area has the highest concentration of water organic matter with an average of 34.476 mg/l and the lowest concentration is at Station VI with an average of 27.934 mg/l. The concentration of total organic matter in the waters of Rupat Island is much higher than in the waters of the Rokan River.

The high concentration of nitrate, phosphate, and organic matter in Rupat Island waters is thought to be due to anthropogenic activities in the Rupat Island area. In the Rupat Island area, there are many Palm Oil, Rubber, and agricultural plantation activities, especially in the Station area located in the Station I, Station II, and III areas in the Rupat Strait area. Hamuna[7] states that apart from naturally, phosphate sources in waters are thought to come from human activities, such as domestic waste disposal, and other activities as well as water overflows from community agricultural activities that have been going on for a long time. Concentration increases with the influx of domestic, industrial, and agricultural or plantation waste that contains a lot of phosphates, crushed organic matter, and phosphate minerals.

Many factors contribute to the high nitrate and phosphate values in the Rupat Island area. The high phosphate concentration is also related to the current. High currents can cause a resuspension process. The resuspension process can cause sediments on the seabed to rise into the water column and cause chemical elements including phosphate and phosphate to also be lifted into the water column. Sediment resuspension is one process that has the potential to contribute nutrient inputs such as nitrate and phosphate from sediments to the water column[8].

Based on the quality standards for nitrate and phosphate content in waters in Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning the Implementation of Environmental Protection and Management, the nitrate content in the Rupat Island area has mostly exceeded the quality standards, where the quality standard for nitrate concentration for marine biota is 0.06 mg/L for nitrate and 0.015 mg/L for phosphate

Phytoplankton Abundance

The lowest phytoplankton abundance was found in the Station II area with an average abundance value of around 416.67 cells/l, while the highest average abundance was found in the Station V area with an average value of 993.05 cells/L. Phytoplankton from the Bacillariophycea class dominate the waters of the Rupat Island area. Phytoplankton from the Bacillariopyceae Class can adapt to changes in aquatic environmental conditions that are very high, this is supported by Wiyarsih[9] this Bacillariopyceae class can survive in polluted environmental conditions in this area there are many factories and residential waste. This is what makes the phytoplankton population in the waters of Rupat Island very dominant compared to phytoplankton from the Cyanophyceae class and phytoplankton from the Conjugatophyceae class. For more details, please see Table 1.

Table 1. Phytoplankton abundance values

Kelas	Jenis	Rata-Rata Kelimpahan Fitoplankton (Sel/l)					
		Stasiun I	Stasiun II	Stasiun III	Stasiun IV	Stasiun V	Stasiun VI
Bacillariophyceae	*Nitzchia sp*	20,83	6,94	0,00	104,17	48,61	0,00
	Synedra ulna	27,78	62,50	6,94	20,83	145,83	0,00
	Itshmia obliquata	48,61	6,94	62,50	97,22	69,44	62,50
	Rhabdonema adriaticum	0,00	20,83	0,00	20,83	83,33	0,00
	Grammatophora sp	41,67	34,72	69,44	83,33	62,50	76,39
	Guinardia striata	62,50	13,89	0,00	20,83	20,83	0,00
	Rhizosolenia alata	27,78	90,28	41,67	0,00	76,39	104,17
	Cyclotella atomus	83,33	6,94	13,89	0,00	55,56	6,94
Cyanophyceae	*Oscillatoria sp*	20,83	0,00	69,44	20,83	13,89	41,67
	Lyngbya sp	34,72	131,94	55,56	34,72	76,39	69,44
	Tolypothrix sp.	0,00	0,00	20,83	111,11	118,06	69,44
Conjugatophyceae	*Pleurotaenium sp.*	20,83	0,00	125,00	27,78	76,39	41,67
	Closterium sp	6,94	20,83	6,94	0,00	76,39	83,33
	Gonatozygon sp.	41,67	20,83	0,00	0,00	69,44	27,78
Jumlah		**437,50**	**416,67**	**472,22**	**541,67**	**993,05**	**583,33**

Based on Table 1, it can be seen that the lowest phytoplankton abundance is found in the Station II area with an average abundance value of around 416.67 cells/L, while the highest average abundance is found in the Station V area with an average value of 993.05 cells/L. Phytoplankton from the Bacillariophycea class dominate the waters of the Rupat Island area. The dominance of phytoplankton from the Bacillariophycea Class. Phytoplankton from the Bacillariopyceae Class can adapt to changes in environmental conditions that are very high. Station I is an area of oil palm plantations, community and company rubber plantations, agricultural sites, and community settlements, so it is thought to get a source of nutrient supply from the mainland.

According to Romimohtarto & Juwana[10], the Cyanophyceae class is less important in marine waters and is more widespread in freshwater and brackish water.

The decline in phytoplankton abundance in the Station II area is thought to be related to the lack of sunlight entering the waters. This is due to the Station II area being a Roro harbor area where at any time the waters are stirred up by ship shipping activities, to increase the value of water turbidity concentration. This is in line with the statement of Tomascik et al. *in* Rimper[11], the increase and growth of phytoplankton populations in waters is related to the availability of nutrients and light.

Station III has almost the same water characteristics as the Station II area where both are in the waters of the Rupat Strait and are filled with ship shipping activities, to increase the value of turbidity concentration of waters. Station III itself is a port area, where transportation activities occur at any time as well as the conditions of the Station II area.

This makes the characteristics of phytoplankton abundance in the Rupat Strait not much different, it is thought to be caused by the movement of water masses which makes the distribution of phytoplankton abundance in the Rupat Strait area not much different. This is supported by the statement of Fitriyah et al.[12] which states that the movement of water masses is also related to the distribution of phytoplankton due to the passive movement of phytoplankton in the waters. Station I, Station II, and Station III areas are known for their sea transport activities because this area is directly opposite Sumatra Island. So that the waters experience stirring and increase the turbidity value of the waters, thereby reducing the penetration of sunlight into the waters. Rimper[11], the increase and growth of phytoplankton populations in waters is related to the availability of nutrients and light.

The high abundance of phytoplankton in the Station IV area compared to Station I, Station II, and Station III in the Rupat Strait is thought to be due to the fulfillment of sunlight requirements for phytoplankton to photosynthesize. Station V has similar water characteristics to Station IV where both are in the Malacca Strait area where the Malacca Strait area has a relatively higher phytoplankton abundance value than the phytoplankton abundance in the Rupat Strait area. This is what is thought to make the Station V area have the highest abundance value in the Rupat Island area due to the penetration of light into the water. According to Abida[13] if the penetration of light into the water is reduced, it will greatly reduce the activity of phytoplankton in photosynthesis. This statement is in line with Sudiana[14] that phytoplankton need sufficient light for the photosynthesis process and the process is also influenced by the surrounding environmental conditions.

In addition, the high value of phytoplankton abundance in the Station V area is also thought to be caused by hydro-oceanographic conditions in the estuary that can have an impact on the distribution pattern of nutrients in the waters. This is because the Station V area is located right in the Cingam River Estuary area which divides along Rupat Island, thus providing more fertile waters than other areas. This is supported by Fitriyah[12] which states that estuarine fertility can be influenced by excess nutrient input from rivers and the sea. Nutrients are nutrients needed for the metabolic and photosynthetic processes of aquatic organisms such as phytoplankton.

Fitriyah[12] also stated that the Estuary is dynamic waters dominated by tides and water mass input from river waters. The estuary area includes a transition area between fresh and salty waters, so these waters are classified as fertile waters. Changes in the proportion of nutrients in the estuary cause changes in the composition of the waters and the organisms in them. So that the estuary is an area rich in nutrients so this area is used as a nursery ground and a feeding ground for aquatic biota.

Station VI also has similar characteristics to Station IV and Station V, where this area is an area in the waters of the Malacca Strait. So the abundance of phytoplankton at Station VI is the second highest compared to stations after the abundance value of Station V, this is thought to be caused by the presence of shrimp pond activities besides that the Station VI area is upstream from the Sei Cingam River Estuary area while the Station V area is downstream from the Cingam River Estuary area besides that, the Station IV area is adjacent to small islands such as the Babi Island area.

The Relationship of Nitrate, Phosphate and Organic Matter Concentrations to Phytoplankton Abundance

The relationship of nitrate concentration to phytoplankton abundance forms the equation Y = 929.151 - 3194.045, with a determination value (R^2) for nitrate to phytoplankton abundance of 0.080, which means that phytoplankton abundance is influenced by nitrate content by 8%. The weak relationship between nitrate concentration is also the same as the results of research conducted by Nasution et al.[15] in Morosari Waters, Demak obtained the results of the relationship between phytoplankton abundance and nitrate content classified as a weak category with the coefficient of determination (R^2) of nitrate with phytoplankton abundance of 0.07 which indicates that phytoplankton abundance in Morosari Waters, Demak is influenced by nitrate concentration by 7%.

Meanwhile, the relationship between phosphate concentration and phytoplankton abundance in Rupat Island waters forms the equation Y = 1025.645 -4054.525, with a determination value (R^2) for phosphate to phytoplankton abundance of 0.105, which means that phytoplankton abundance is influenced by nitrate content by 10.5%. Similar to nitrate concentration, the relationship between phosphate concentration and phytoplankton abundance is also weak. This is in line with research conducted by Gustina[16] in the Upang River Estuary Waters based on the results of simple regression analysis, it was found that the relationship between phosphate and phytoplankton was 0.0934, which has a very weak relationship.

Furthermore, the relationship of organic matter content to phytoplankton abundance forms the equation Y = 1122.459 - 18.468. The determination value (R^2) for water organic matter on phytoplankton abundance is 0.033 which means that phytoplankton abundance is influenced by nitrate content by 3.3%. In line with the research of Rasmiati et al.[17] who conducted research in the Estuary Waters of the Dumai River, Riau Province, the results of the regression test of the relationship between total organic matter content and phytoplankton abundance at each station were shown by the mathematical equation Y = 3772.9 - 91.459x with the coefficient of determination (R^2) = 0.1097 and the correlation coefficient (r) = 0.33. The mathematical equation states that the relationship between total organic matter content and phytoplankton abundance is inversely proportional in the waters of the Dumai River estuary.

Wulandari[18] also stated that the higher the total organic matter content, the lower the phytoplankton abundance in the waters of Jobokuto Bay, Jepara Regency, Central Java. The relationship between phytoplankton abundance and the concentration of nitrate, phosphate, and water organic matter content in the waters of Rupat Island is very weak where the relationship ranges from 8%, 10.5%, and 3.3%. The division of water areas based on phytoplankton abundance, Rupat Island water area is included in the category of oligotrophic waters, where the level of fertility is moderate with phytoplankton abundance of 0 - 2,000 cells/L of the total abundance of research stations. Phytoplankton abundance in the Rupat Island water area is thought to be closely related to other parameters such as brightness, turbidity, and TSS concentration which can interfere with photosynthesis. In line with the statement of Wisha et al.[19], the distribution of higher TSS concentrations and turbidity will cause obstacles to the reach of sunlight penetrating the waters, this can interfere with the photosynthesis process carried out by autotroph biota (primary producers).

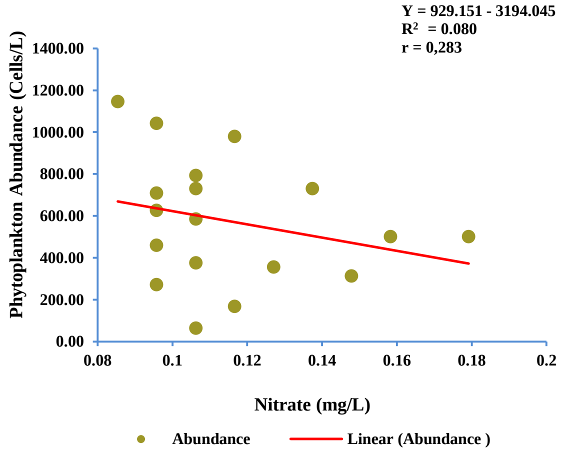

Figure 5. Nitrate on phytoplankton

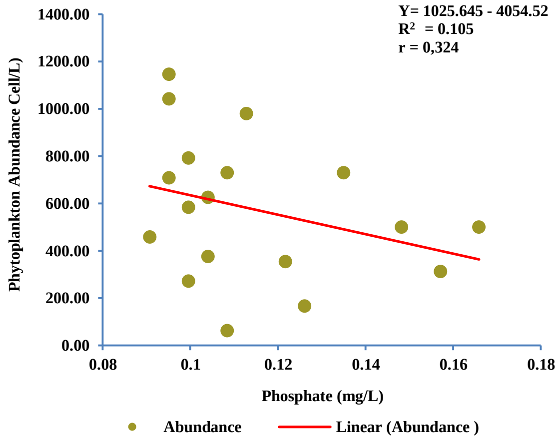

Figure 6. Phosphate on phytoplankton

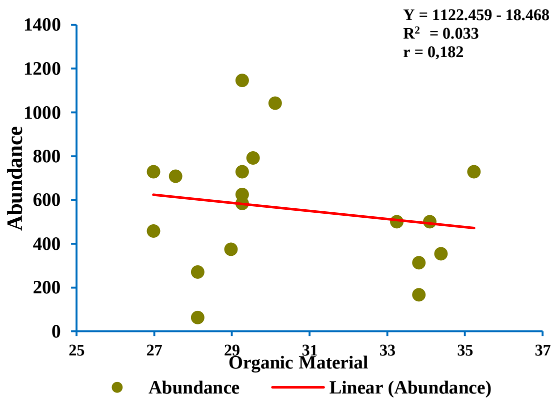

Figure 7. Organic matter on phytoplankton

Phytoplankton abundance in the Rupat Strait waters is lower than in the Malacca Strait. While nitrate and phosphate concentrations in the Rupat Strait area are higher than in the Malacca Strait area, this is due to high rainfall in September where nitrate and phosphate enter the Rupat Strait waters sourced from anthropogenic activities on the mainland of Rupat Island such as Palm Oil plantations, Coconut, and agricultural activities will increase nitrate and phosphate concentrations but also increase TSS concentrations, turbidity, and water brightness. This is suspected to be the cause of the ineffectiveness of the relationship between phytoplankton abundance and nitrate phosphate concentrations. Meirinawati & Muchtar[2], high rainfall causes an abundance of nutrients such as nitrate and phosphate in the waters.

In addition, water quality parameters are thought to affect phytoplankton abundance besides nitrate and phosphate concentrations such as depth, water brightness, temperature, salinity, and dissolved oxygen. This is supported by the statement of Sundari[20] phytoplankton also depends on the condition of several factors, such as depth, brightness, temperature, current, salinity, pH, dissolved oxygen (DO), and nutrients. To see the relationship graph of nitrate concentration to phytoplankton abundance (Figure 5), the relationship graph of phosphate concentration to phytoplankton abundance

(Figure 6), and the relationship graph of organic matter content to phytoplankton abundance (Figure 7).

4. CONCLUSION

Based on the results of the study, the relationship between nitrate, phosphate, and organic matter content with phytoplankton abundance in the Rupat Island area is not significant or weak with the coefficient of determination (R^2) 8%, 10.5%, and 3.3%.

It is necessary to monitor coastal areas so that waste does not directly enter coastal waters employing intensive supervision from local governments

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