Asian Journal of Aquatic Sciences, August 2023. Vol 6, Issue (2) 274-280
e-issn: 2716-4608
p-issn: 2655-366X

RELATIONSHIP BETWEEN PRIMARY PRODUCTIVITY OF PHYTOPLANKTON AND NUTRIENTS IN COASTAL WATERS, PELINTUNG VILLAGE, MEDANG KAMPAI DUMAI DISTRICT

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ABSTRACT

This study is to determine the relationship between primary productivity and nutrients in the coastal waters of Pelintung Village, Medang Kampai District, Dumai. The research was conducted in March 2022; the method used in this research is survey method and purposive sampling. The research location is divided into 3 station points namely tourist area, secondary vegetation forest area, and near industrial area. The results of the measurement of the highest primary productivity value are found at Station III which is 78.91 mgC/m^2/hour which indicates mesotrophic water conditions, while the lowest primary productivity value is at Station II, which is 46.88 mgC/m^2/hour which indicates oligotrophic water conditions. The results of the analysis of the concentration of nitrate and phosphate between stations also varied, namely for the nitrate value of 0.04 – 0.05 mg/L which was included in the less fertile category, while the phosphate concentration was 0.042 – 0.048 mg/L which was included in the fertile category in the waters. Furthermore, the relationship between nitrate concentration and primary productivity is a correlation coefficient value (r) = -0.070 which means that there is a weak relationship between nitrate concentration and primary productivity. Meanwhile, the relationship between phosphate concentration and primary productivity is the correlation coefficient (r) = 0.965, which means that there is a very strong relationship between phosphate concentration and primary productivity. So it can be concluded that nitrate and phosphate nutrients can affect the primary productivity of water.

Keywords: Nitrate, Phosphate, Pelintung Dumai Village Waters, Primary Productivity

1. INTRODUCTION

Pelintung Village in Dumai City is one of the strategic areas and is progressing very fast. The large number of human activities around the area, such as increasing population settlements, ports, household activities, and industrial activities of oil palm plantations is suspected as a carrier of large enough organic or inorganic materials into sea waters which can disrupt water quality[1].

Primary productivity provides the flow of energy in the waters through the process of photosynthesis which is needed by aquatic organisms for survival. The amount of primary productivity also increases the amount of phytoplankton which can determine the level of water fertility. The high number of phytoplankton in waters can illustrate that these waters have a good level of fertility and can guarantee the life of aquatic organisms sustainably; the low number of phytoplankton in waters causes a break in the food chain which has an impact on the survival of a waters and decreases the quality of a waters[2].

Nitrate and phosphate are nutrients in marine waters which are generally used as indicators of phytoplankton growth. Nitrate

Received : 19 May 2023
Accepted : 30 July 2023

is a nutrient that is used in several processes such as photosynthesis, synthesis of protein, and as a constituent of genes and the growth of organisms. Nitrate is the main form of nitrogen in water and is the main nutrient needed for plant and algae growth. Nitrate in the waters comes from the breakdown of organic and inorganic nitrogen in the soil which comes from the decomposition of organic matter with the help of microbes[3].

Phosphate in the form of phosphorus can be utilized by plants and is an essential element for higher plants and algae so it can affect the level of aquatic productivity. Sources of phosphorus in waters and sediments are phosphorus deposits, industry, domestic waste, agricultural activities, phosphate rock mining, and deforestation[4].

Increasing nutrient supply and availability of nitrate and phosphate nutrients are water chemistry factors that can affect primary productivity, through the decomposition process, organic matter will be broken down into nutrients[5]. In general, the main source of nitrate and phosphate that enters the waters is waste originating from the mainland in the form of industrial and residential waste containing organic compounds that flow through rivers[6].

The aims and benefits of this study were to determine the relationship between the primary productivity of phytoplankton and nutrients in the coastal waters of the Pelintung Village, Medang Kampai District, Dumai.

2. RESEARCH METHOD

Time and Place

This research was conducted in March 2022. The location for water sampling was carried out in the coastal waters of the Pelintung Village, Medang Kampai District, Dumai. Measurement of physicochemical parameters of water and analysis of primary productivity water samples were carried out directly at the research location, and analysis of Nitrate and Phosphate water samples was carried out at the Marine Chemistry Laboratory, Faculty of Fisheries and Marine Sciences, Universitas Riau.

Method

The method used in this research is a survey method for observation and sampling. Determination of research locations using a purposive sampling method. Sampling and observations were carried out directly in the field.

Procedure

Determination of Locations and Sampling Points

The sampling location was carried out by purposive sampling by setting 3 stations. Observation locations based on the characteristics of area activities that are suspected of influencing the waters around which consist of Station I: Tourism Area, Station II: Forest Area (secondary vegetation), and Station III: Area near Industry

Water Sampling for Nitrate and Phosphate Analysis

Water sampling for nitrate and phosphate analysis using a sample bottle. 100 ml of water samples were taken on the surface, for nitrate analysis water samples were given 2 drops of H_2SO_4 solution. Then the bottles are wrapped using aluminum foil, then labeled, and put in an ice box for analysis in the laboratory.

Water Quality Measurement

Water quality measurements measured are temperature, pH, salinity, dissolved oxygen, current speed, and brightness. Measurements were made 3 times at each sampling point.

Nitrate and Phosphate Analysis

The procedure for measuring nitrate concentrations, the water sample being analyzed was filtered first as much as 10 ml using Whatman No.42 filter paper and then put into a test tube, the water sample in the test tube was dripped with 4 drops of

EDTA solution then filtered again using a cadmium filter. After filtering, 10 drops of sulfonamide acid and 10 drops of naptilamide solution were dripped. Then note the pink color change in the test tube, after that, the test tube is inserted into the spectrophotometer to measure the absorbance with a wavelength of 543 nm.

Then to measure the Phosphate value, the water sample analyzed was filtered first as much as 12.5 ml using Whatman No.42 filter paper and then put into a test tube. The sample in the test tube is dripped with 10 drops of Ammonium molybdate and 10 drops of $SnCl_2\,2H_2O$ then homogenized and waited for about 2 minutes. Absorbance with a wavelength of 690 nm.

Phytoplankton Primary Productivity

Primary productivity in water is measured using dark bottles and light bottles. A sampling of primary productivity water was carried out at each station using a bucket, and then the water samples were transferred to each of the initial bottles, dark bottles, and light bottles until they were full without bubbles. The water sample in the initial bottle is measured as the initial dissolved oxygen level. Then the dark bottles and light bottles which are filled with water samples are tied using a rope and then put into seawater, then incubated for 4 hours in seawater. After incubation for 4 hours, then lifted to the surface, then the dissolved oxygen in the dark bottle and the light bottle was measured as the final dissolved oxygen level by the titration method.

Primary productivity analysis was carried out directly at the study site, according to the dissolved oxygen analysis procedure. According to Syafrizal et al.[7], the measurement of primary productivity can be found using the following formula:

$$PPB=\frac{(DObt\text{-}DOa)\times 1000\times 0{,}375}{t\times PQ}$$

$$PPK=\frac{(DObt\text{-}DObg)\times 1000\times 0{,}375}{t\times PQ}$$

$$R=\frac{(DOa\text{-}DObg)\times 1000\times 0{,}375}{t\times PQ}$$

Information:

PPB = Net primary productivity (mgC/m^2/hour)
PPK = Gross primary productivity (mgC/m^2/ hour)
R = Respiration (mgC/m^2/hour)
PQ = Coefficient of photosynthesis (1,2)
t = Time (hours)
DOa = Oxygen Level at the beginning of the measurement (mg/l)
DObt = Oxygen level in the light bottle at the end of the measurement (mg/l)
DObg = Oxygen level in the dark bottle at the end of the measurement (mg/l)
1000 = Convert L to m^2
0.375 = Coefficient of conversion of oxygen to carbon (12/32)

Data Analysis

Data obtained from research on physic-chemical environmental parameters, primary productivity values, and nitrate and phosphate concentration values are discussed descriptively and presented in tables and graphs. The analysis was carried out with the help of Microsoft Excel Software and the Statistical Package for Social Science (SPSS).

Furthermore, a regression test was carried out to see whether or not there was a relationship, how the direction of the relationship was, and how strong the relationship was between the two variables (the independent variable and the dependent variable). The regression equation used is:

$$Y = a + bx$$

Information:

Y = Dependent Variable (primary productivity)
a,b = Constants and Regression Coefficients
x = Independent Variable (nitrate and phosphate)

To find out the density of the relationship, the correlation coefficient (r)

is used where the value of r is between 0 – 1. The closeness of the values is:

0.00 – 0.25 = Weak Relationship
0.26 – 0.50 = Moderate Relationship
0.51 – 0.75 = Strong Relationship
0.76 – 1.00 = Very strong relationship

3. RESULT AND DISCUSSION

Water Quality Parameters

Changes in water quality between stations are related to activities around the waters which from the measurement results can determine the quality of water. The results of measuring water quality parameters can be seen in Table 1.

Based on Table 1, it can be seen that the water temperature ranges from 29-30℃, the lowest is at station III which is 29℃ while the highest is found at station I which is 31℃. The pH value between stations is 8-9. Salinity values are between 20-22 ppt. the current speed is 0.13-0.17 m/s. Brightness ranges from 14.5-23 cm. The highest dissolved oxygen was at station III, which was 8.57 mg/L and the lowest was at station I, which was 3.88 mg/L

Table 1. Water quality measurement

No	Parameter	Station		
		I	II	III
1	Temperature (℃)	31	30	29
2	pH	8	9	9
3	Salinity (ppt)	20	21	22
4	Current Speed (m/s)	0.15	0.13	0.17
5	Brightness (cm)	23	21	14.5
6	Dissolved Oxygen (mg/L)	3.88	4.89	8.57

Table 2. Average value of primary productivity (mgC/m^2/hour)

Station	Net primary productivity	Respiration	Gross primary productivity
I	64,84	48,83	113.67
II	46,88	33.59	80.47
III	78,91	48,44	127,34

Primary Productivity Measurement

The measurement results for the value of primary productivity between stations in the waters of the Pelintung Village, Medang Kampai District, Dumai (Table 2).

Based on Table 2, it can be seen that the primary productivity values between research stations ranged from 46.88 – 78.91 mgC/m^2/hour. The highest primary productivity value was found at Station III, namely 78.91 mgC/m^2/hour, which indicates that the waters at this station are in the mesotrophic waters category. Meanwhile, the lowest primary productivity value was at Station II, namely 46.88 mgC/m^2/ hour.

The high value of primary productivity at Station III is affected by the current speed at this station which is faster than Stations I and II. According to Qurban et al.[8], this upward movement of current velocity brings with it colder temperatures and high salinity water. Based on the research that has been done, the temperature value is lower than the two stations and the salinity value is higher than the two stations. At the time of measuring the value of primary productivity at this station, the condition of seawater in this area was high tide, the value of primary productivity at Station III should be lower than at Stations I and II, but due to the process of high tide and fast current speed, the value of primary productivity at this station becomes high.

The lowest primary productivity value was found at Station II, namely 46.88 mgC/m^2/hour. Factors affecting the low water productivity at this station are related to the high value of primary productivity at

Station III, where water at Station III flows into the waters of Station II. Factors inhibiting primary productivity are carried by the water such as household wastewater from rivers, oil spill waste from ships, and sediments in waters that are contaminated with toxic metals.

Nitrate and Phosphate Concentration Analysis

Based on the results of the analysis that has been carried out, the concentration values for Nitrate and Phosphate nutrients in the waters of the Pelintung Village, Medang Kampai District, Dumai can be seen in Table 3.

Table 3. Value of nitrate and phosphate concentration (mg/L)

Station	Nitrate concentration	Phosphate concentration
I	0.0437	0.0442
II	0.0542	0.0420
III	0.0542	0.0487

Based on Table 3, the values of nitrate concentrations between stations ranged from 0.04 mg/L – 0.05 mg/L. The results of the analysis of the highest nitrate concentrations were found at Stations II and III, namely 0.0542 mg/L, in this study, Station II was an area of secondary vegetation forest which was not far from the industrial area, while Station III was an area close to the palm oil mill industry. The high value of nitrate concentrations at these two stations compared to Station I is due to activities in these two areas which can affect high nitrate concentration values, the condition of the area at Stations II and III is also close to rivers that empty into sea waters which are suspected of carrying industrial waste and household waste in the vicinity of the river. According to Hamuna et al.[9] (2018), the input of high organic matter from land activities can be in the form of land erosion, the input of household waste, agricultural waste in the form of residual fertilizers, and others which are carried directly into sea waters or through rivers.

Based on the results of the analysis that has been carried out, the phosphate concentration values between stations ranged from 0.042 – 0.048 mg/L. The highest concentration of phosphate is found at Station III, which is in the area near industrial areas, while the lowest concentration of phosphate is found at Station II, which is an area of secondary vegetation forest. The high value of phosphate concentration at Station III is because this station is an industrial area. According to Sitorus et al.[10], phosphate nutrients are produced from domestic waste, as well as plantation waste that enter the waters.

Relationship of Nitrate and Phosphate Nutrients with Primary Productivity

The results of measurements of nitrate concentrations between stations ranged from 0.04–0.05 mg/L, while the values for primary productivity between stations ranged from 46.88–78.91 mgC/m^2/ hour. The results of the regression test of nitrate concentrations with primary productivity between stations are shown by a mathematical equation, namely Y=-185.24x + 72.935, which can be seen in (Figure 1).

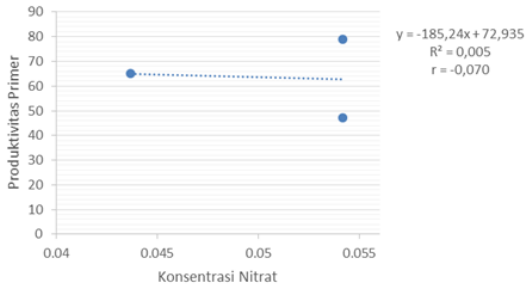

Figure 1. Relationship between nitrate concentration and primary productivity

The results of linear regression of the relationship between nitrate concentration and primary productivity showed a negative value (-). Negative values indicate an inverse relationship between primary

productivity and nitrate values. Furthermore, the value of the correlation coefficient (r) = -0.070, which means that 7% of the nitrate concentration variable affects the primary productivity variable. The results of value analysis (r) indicate a weak relationship between nitrate concentrations and primary productivity. Based on the above equation, the coefficient of determination (R^2) = 0.005 is obtained. This indicates that the nitrate variable has a 5% effect on primary productivity.

The results of measuring the concentration of phosphate values between stations were 0.042–0.048 mg/L and the values of primary productivity between stations were in the range of 46.88–78.91 mgC/m^2/hour. The results of the phosphate concentration regression test with primary productivity between stations are shown by a mathematical equation, namely Y =4536x-140.42 which can be seen in (Figure 2).

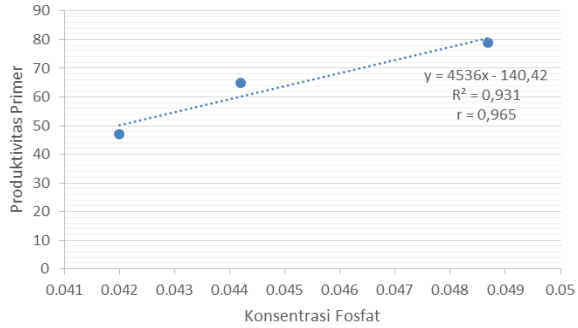

Figure 2. The relationship between phosphate concentration and primary productivity

The results of linear regression of the relationship between phosphate concentration and primary productivity showed a positive (+) value. A positive value indicates a unidirectional relationship between phosphate concentration and primary productivity, with a correlation coefficient (r) of 0.965, which means that 96% of the phosphate concentration variable affects the primary productivity variable. The results of value analysis (r) show a very strong relationship between phosphate concentration and primary productivity. Based on the equation above, the coefficient of determination (R^2) is 0.931. This indicates that the phosphate variable has a 93% effect on primary productivity, while 7% is influenced by other factors not tested in this study.

4. CONCLUSION

The relationship between nitrate concentration and primary productivity shows a mathematical equation Y=-185.24x + 72.935 with a value of (r) -0.070 which indicates a weak relationship, while the relationship between phosphate concentration and primary productivity shows a mathematical equation Y = 4536x - 140.42 with (r) 0.965 which indicates a very strong relationship.

Further research is needed by adding observations of other aquatic nutrients such as ammonia, silicates, sulfates, and dissolved metals which can affect the value of primary productivity produced in the waters, and also look at the abundance of phytoplankton in the waters of the Pelintung Village, Dumai

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