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Analysis of Microalgae Growth Based on Availability of Nutrients in Freshwater

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ABSTRACT
Microalgae have the potential to developed into medicinal products, wastewater treatment, food and energy products. Indonesia is a tropical country has the potential to produce microalgae. The growth of microalgae was influenced by several factors, the main factors is nutrition. This study aims to produce a pattern of mathematical relationships between microalgae growth and nutrient availability of the Laut Tawar Lake. Data collection was carried out for 30 days with a frequency of 7 days at 7 stations. Furthermore, the analysis was carried out to obtain concentration values of nitrate, phosphate and chlorophyll-a. Nitrate concentrations during the study ranged from 310-430 µg/L. The lowest average nitrate concentration was found at Station 4, which was 330 ± 34.64 µg/L and the highest was found at Station 3, which was 396.67 ± 41.63 µg/L. Phosphate concentrations during the study ranged from 18 – 22 µg/L. The highest phosphate concentrations were found at Station 1 and Station 6, which were 20.67 ± 0.58 µg/L and 20.67 ± 1.53 µg/L, and the lowest were found at Station 3, which were 19.00 ± 1.00 µg/L. The concentration of chlorophyll-a ranges from 5 – 12 µg/L. The highest average concentration of chlorophyll-a was obtained at Station 6, which was 10.00 ± 1.00 µg/L and the lowest was found at Station 3, which was 7.00 ± 2.00 µg/L. In conclusion, increasing nitrate in the Lake Laut Tawar did not increase microalgae biomass, microalgae species in that habitat were influenced by nutrient phosphate.

Keywords: *Microalgae, Phosphate, Nitrate, Chlorophyll-a, Laut Tawar Lake*

1. INTRODUCTION

This decade, the study of microalgae is an important topic. Microalgae have the potential to be developed into products that are beneficial for human life, such as a source of drugs and wastewater treatment [1]. A very important effort to use microalgae is also directed as raw material for food and energy products. This step is to overcome the condition of the world, which has been hit by a food and energy crisis.
Microalgae are one of the organisms that have enormous potential to be developed both in the food and fermentation industries. Microalgae are organisms that contain chlorophyll and other pigments so that they can do photosynthesis. Microalgae are widespread in nature and can be found in almost all environments exposed to sunlight [2]. Microalgae growth is influenced by several factors, one of which is nutrients. Research on the identification and abundance of microalgae in freshwaters, especially the Central Aceh. Laut Tawar Lake has been carried out, where data is obtained about the amount and diversity of microalgae in these waters. The waters of the Laut Tawar Lake have one type of microalgae that has an oil content of 45–47% by dry weight, namely Nitzschia sp. [3]; [4]; [5]. Microalgae growth patterns based on nutrients available in the Laut Tawar Lake have not been carried out. The selection of the location was made by considering the area of the large freshwater location, which only exists in the lake in Aceh Province. Another consideration is that the lake also contains sufficient nitrogen and phosphorus content for microalgal growth [6].

This study aims to produce a mathematical relationship between microalgal growth and the availability of nutrients in fresh waters, especially in Laut Tawar Lake. The mathematical equation obtained from this study is a new theoretical concept that will help researchers related to microalgae production research, which will be able to predict the amount of microalgae growth based on the nutrients given.

2. MATERIAL AND METHOD

The materials used in the study were motorboats, sample bottles, van dor samplers, and box styrofoam. This study

was conducted in September–October 2022 in Lake Laut Tawar, Takengon, Central Aceh. The stages of the implementation of research in general consist of (1) preparation, (2) data collection, and (3) data analysis. The preparation stages consist of (a) administrative preparation in the form of handling assignment letters and research permits in the field, and (b) technical preparation, in the form of determining the point of observation stations, preparing tools and materials, and ensuring laboratory readiness. Data collection was carried out for 30 days with a 7-day frequency at 7 stations of observation. During this time span, 21 pieces of data will be collected for each parameter.

The research parameters analyzed are phosphate, nitrate, and chlorophyll-a. Data analysis is done by utilizing simple regression analysis and multiple regression analysis. Simple regression analysis is carried out to get a relationship between microalgal growth to each TN, TP, and TN/TP parameter. Multiple regression analysis is carried out to get a relationship between microalgae growth to two parameters, namely Mr. and TP. Multiple regression analysis between microalgae growth and 3 parameters, in the form of Mr. TN, TP, and TN/TP ratio.

3. RESULT AND DISCUSSION

3.1 Nitrate

Nitrogen is one of the important elements for growth, development, reproduction, and microalgal activities [7]. Nitrate is a nutrient that increases the growth and biomass of microalgae [8], but it depends on the microalgae species [9]. The concentration of nitrates in the waters of Laut Tawar Lake during the study ranged from 310 - 430 µg/l. This value is spread over the 7 observation stations showed in Figure 1.

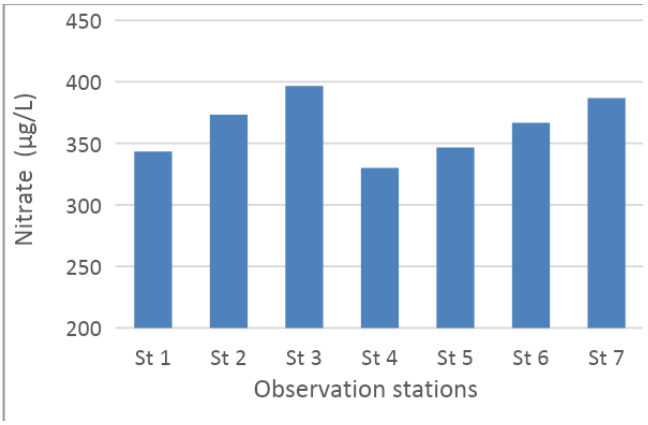


Figure 1. Nitrate concentration according to the observation station

The lowest average nitrate concentration is obtained at station 4, which is 330 ± 34.64 µg/l with a range of values between 310-370 µg/L. The highest nitrate concentration is found at station 3, which is 396.67 ± 41.63 µg/l and the range of values between 350 - 430 µg/L. The variation in nitrate concentration quantitatively is thought to be influenced by the closest inlet source to the observation station. The comparative test was carried out by the Kruskall-Wallis test, which showed that the concentration of nitrate was no different. This shows that the concentration of nitrates has the same relative value in all parts of the water observed at the same time. This condition is influenced by the wind factor that causes a mixture of lake water on the surface [10] [11].

3.2 Phosphate

Microalgae growth is strongly influenced by the nutrient phosphorus, waters that have a phosphorus concentration up to 0.01 mg P/L still allow microalgae to grow [12]. Phosphate concentration in the waters of Laut Tawar Lake during research ranges from 18-22 µg/l. The value of phosphate at the 7 observation stations is shown in Figure 2.

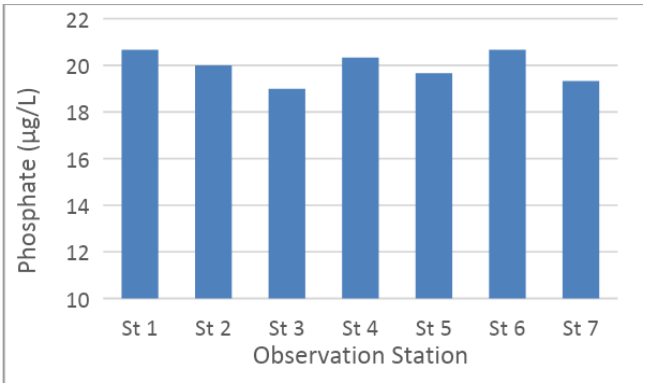


Figure 2. Phosphate concentration according to the observation station

The highest phosphate concentration is found in stations 1 and station 6, which are 20.67 ± 0.58 µg/L and 20.67 ± 1.53 µg/L. Phosphate concentration at station 1 ranges from 20 - 21 µg/L and station 6 ranges from 19-22 µg/L. The lowest phosphate concentration is found at station 3, which is 19.00 ± 1.00 µg/L, with a range of values between 18-20 µg/L. Like nutrient nitrate, this nutrient phosphate is also thought to vary quantitatively depending on the location of the nearest source of the inlet to the observation station. The wind is one of the factors that influence the mixture of the surface water of the lake [10]; [11].

3.3 Chlorophyll-a

Chlorophyll-A describes microalgal biomass [13]; [14]; [15]. Chlorophyll-A concentrations in the Laut Tawar Lake during the study ranged from 5–12 µg/l. The value of chlorophyll-a at 7 observation stations is shown in Figure 3.

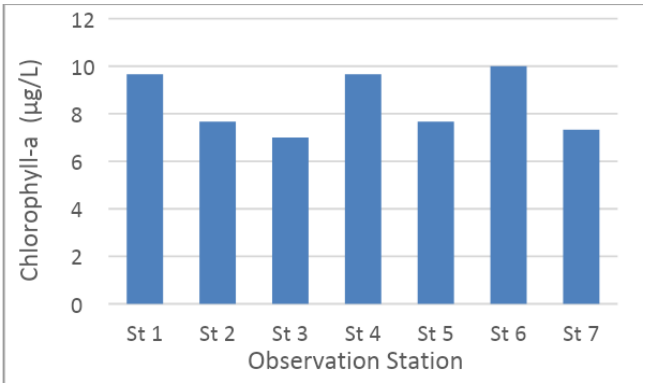


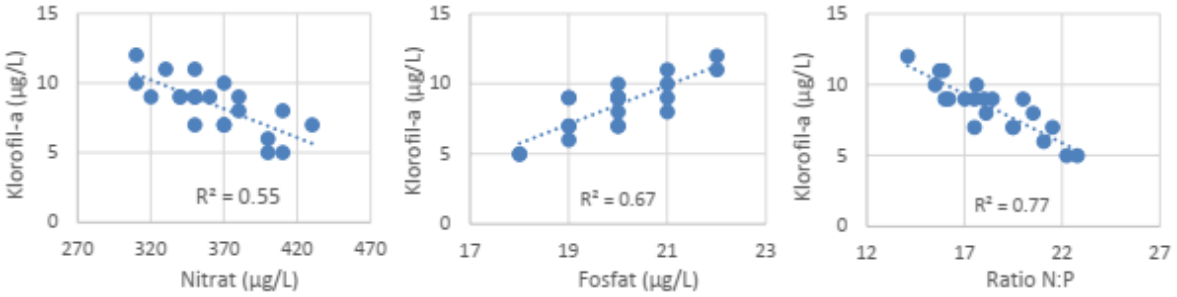
Figure 3. Chlorophyll-a concentration according to the observation station

The highest average chlorophyll-A concentration is obtained at station 6, which is 10.00 ± 1.00 µg/L with a range of values between 9-11 µg/L. The lowest chlorophyll-a concentration is found at station 3, which is 7.00 ± 2.00 µg/l with a value ranging from 5–9 µg/l. The variation in chlorophyll-a concentration is thought to be influenced by the source of the inlet that flows a number of nutrients to the observation station.

3.4 Correlation of Nutrients and Chlorophyll-A

Microalgal growth is influenced by nitrogen (N) and phosphorus (P) nutrients [16]; [17], where the concentration of phosphorus and nitrogen affects the abundance of microalgal biomass[18]. The effect of nutrients on microalgal growth can be known by observing the relationship formed between nutrients and chlorophyll-a. Ratio N: P is obtained by dividing the value of nitrate concentration with phosphate concentrations obtained with a range between 14.09-22.78 and an average of 18.31 ± 2.40. Correlation Analysis with Pearson Test on Relations of Nitrate-Chlorophyll-A, Phosphate-Chlorophyll-A, and Ratio N: P-Chlorophyll-A shows the correlation value in a row is -0.74, 0.82, and 0.88. The value of the correlation coefficient shows a very strong correlation [19]. The

linearity test also shows that the relationship is formed linearly. The regression test of the relationship is illustrated in Figure 4.



(a) (b) (c)

Figure 4. Correlation of Nutrients and Chlorophyll-A in Laut Tawar Lake

Figure 4 (a) displays the regression relationship between nitrate and chlorophyll-a, which appears that an increase in nitrate concentration results in chlorophyll-A decreasing. This has been stated in the negative correlation coefficient. This condition is different from the statement that nitrate will increase the growth and biomass of microalgae [8]. The waters of Laut Tawar Lake show a decrease in microalgal biomass (chlorophyll-a) with an increase in nitrate. This is due to the fact that the microalgae species that live in the Laut Tawar Lake are different from those in sea waters, thus affecting the use of nitrates [9]. The determinant coefficient (R2) of the relationship between nitrate and chlorophyll-A of 0.55 shows that about 55 percent of nitrate nutrients cause a decrease in microalgal biomass, whereas the rest is influenced by other factors.

The opposite condition is shown in Figure 4(b), where it appears that an increase in nutrient phosphate is followed by an increase in microalgal biomass (chlorophyll-a). This is in line with the statement that phosphorus is a primary factor for microalgal growth in reservoirs and lakes [20]; [21]; [22]; [23]. The results of this study indicate that phosphate affects microalgal biomass by 67 percent, which is indicated by the determinant coefficient (R2) of the relationship between phosphate and chlorophyll-a.

In addition, microalgae growth in the lake is limited by the ratio of N:P [24], and the ratio of N:P is a limiting factor for microalgae growth [25]. The correlation between the N:P ratio and chlorophyll-A is shown in Figure 4(c), which illustrates that an increase in the N:P ratio causes a decrease in chlorophyll-A. This is influenced by an increase in nitrates that cause an increase in the ratio of N:P, but nitrate does not cause an increase in chlorophyll-a. Increased chlorophyll-A is only influenced by an increase in phosphate, so it becomes a strong indication that phosphorus is a nutrient limiting for microalgae growth in the Laut Tawar Lake. The ratio N:P in the waters of Laut Tawar Lake during this study shows an average value of 18.31 ± 2.40 µg/L. This value shows that phosphorus is a limiting factor for microalgal growth in the Laut Tawar Lake because the ratio of N:P ≥ 16 becomes an indicator of the limiting nutrient in the aquatic ecosystem [21]; [26].

4. CONCLUSION

Observations during the study showed microalgal biomass in the waters of Laut Tawar Lake represented by the chlorophyll-a concentration of 8.43 ± 1.89 µg/l. Microalgal growth is influenced by the availability of nutrients in these waters, in the form of nitrates and phosphate. Nitrate nutrient found at 363.33 ± 33.67 µg/L, and Nutrient Phosphate of 19.95 ± 1.12 µg/L. Analysis of the relationship between nutrients and chlorophyll shows that the increase in nitrates in the waters of the Laut Tawar Lake does not increase microalgal biomass because the microalgae species in the habitat are influenced by nutrients like phosphate. Phosphorus is a nutrient-limiting microalgae growth in the waters of the fresh sea lake with a mathematical relationship indicated by the chlorophyll-a equation = 1.38 phosphate - 19.10.

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