The Relationship of Phytoplankton Primary Productivity Values with Physical and Chemical Factors in Parapat Waters, Lake Toba

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ABSTRACT

The aim of this research was to investigate the relationship of primary productivity value with the chemistry physical factor Parapat, Lake Toba. Primary productivity in Lake Toba from activity photosynthesis of done by chlorophyll. This research has been done during March 2009 at 3 sampling location around Parapat, Lake Toba. The locations research obtained based on variation activity to obtained location research. Primary productivity was measured by the Oxygen Method were two bottles with a given concentration of phytoplankton (small aquatic organism) are suspended at the depth from which the samples were obtained. The "dark" bottle is wrapped in aluminium foil to exclude light: "light" bottle is clear. A quantity of oxygen proportional to the total organic matter fixed (gross production) is produced by photosynthesis in the light bottle. At the same time, some of oxygen is being utilized in respiration. The other analysis would be conducted to measurement such as temperature, pH, DO, BOD, COD, nitrat, fospat, chlorophyll a, abundant phytoplankton, light penetration, light intensity. The value of primary productivity range from 112,608 - 825,792 mgC/m3/day and with the highest value of primary productivity equal to 825,792 mgC/m3/day obtained at the depth 7 m (station I), the value of chlorophyll equal to 62,013 mg/m3 obtained at the surface (station III) and the lowest value of chlorophyll a equal to 0,801 mg/m3 obtained at the depth 3,5 m (station III), beside the value of phytoplankton equal to 3306,12 ind/l obtained at the depth surface (station I) and the value of phytoplankton equal to 1469,39 ind/. According to statistical the test obtained that there no significance difference of value of primary productivity which is compared between station or depth.

Keywords: Chlorophyll; Phytoplankton; Primary Productivity.

INTRODUCTION

Lake Toba is a water ecosystem that has undergone many changes, especially as a result of several human activities around it. Lake Toba is the largest lake in Indonesia, located in the Bukit Barisan

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mountains with a surface area of ± 112,970 Ha, with the deepest waters ranging from ± 435 m above water level and located at an altitude of ± 995 m above sea level (Department of Fisheries Level I North Sumatra, 1993 ). Furthermore, based on its geographical location, Lake Toba is located between 020 – 030 North Latitude and 980-990 East Longitude.

Lake Toba which is an aquatic ecosystem has various types of aquatic biota life, one of the biota contained in it is phytoplankton. Phytoplankton is a group that plays a very important role in the aquatic ecosystem, because this group with chlorophyll content is able to carry out photosynthesis. The process of photosynthesis in aquatic ecosystems carried out by phytoplankton (producers), is the main source of nutrition for other groups of organisms that act as consumers. In the process of photosynthesis, it will produce energy by utilizing sunlight with organic compounds that support these waters, where the primary productivity of phytoplankton in an aquatic ecosystem acts as an energy generator. In aquatic ecosystems, Barus, 2004, page: 37).

Primary productivity is the capture of solar energy by green plants and the conversion of some of the sun’s energy into chemical energy through photosynthesis. According to Harborne, (1987, pp: 260), Chlorophyll consists of 2 fractions, chlorophyll a with up to 72% content, and chlorophyll b up to 28%. Primary productivity is the rate of production, i.e. quantity per unit time. Photosynthesis affects the absorption of radiant energy and carbon dioxide as well as the release of oxygen. Productivity is limited by the amount of chlorophyll available. Communities can be compared based on the chlorophyll present at any given moment (Michael, 1984, pp.: 366-371). The quality of life in the water is strongly influenced by the quality of the waters themselves as a medium for living aquatic organisms. The worse the quality of the waters, the worse the quality of life in the waters. This means that the communities of organisms that live in clear waters are different from those that live in polluted waters. Water pollution, in recent years has become a serious problem faced by various regions in Indonesia. With the increase in development activities, especially in the industrial sector, it seems that water pollution will continue to be a problem for mankind in the future. Miller (1985), in Soegianto (2004, pp: 1) explains that a water is said to have been polluted, if there is a material or condition (eg heat) that can cause a decrease in the quality of the water (body of water) to a certain level, so that it cannot be used for certain purposes.

The main problem experienced by the Lake Toba ecosystem is primarily a decrease in water quality as a result of various wastes being dumped directly into water bodies, as in Station I which is located on the beach of Dharma Agung Hotel, there is the disposal of domestic/hospitality waste, agricultural waste and oil waste that is disposed of. derived from water transport activity. While in fish ponds / community fish cages (station II) there is waste from aquaculture in floating nets which causes the growth of aquatic plant vegetation to increase and if this happens it can cause water bodies to be covered which in the end can damage the balance of the aquatic ecosystem.

The purpose of the study was to determine the relationship between the primary productivity of phytoplankton and the physical and chemical factors of the waters of Parapat, Lake Toba. The benefits of the research are as follows: a. Provide information for related agencies or parties regarding the relationship between the value of primary productivity of phytoplankton and physical and chemical factors of Parapat, Lake Toba. b. Provide information about biodiversity (especially phytoplankton) as well as various parameters of the biotic environment which can then be used as initial data in monitoring the quality and processing of the Lake Toba ecosystem in general and Parapat waters in particular.

RESEARCH METHOD

2.1 Area Description
This station is located on the beach of Hotel Dharma Agung near the ferry pier carrying passengers, Girsang Sipanganbolon District, which is geographically located at 2039’49.03”N and 98055’42.03”E.
2.2 Station II
This station is ± 5 km from station I, located in the District of Girsang Sipanganbolon which is geographically located at the points 20°39'23.01"N and 98°05'53.02"E. At this location are fish ponds and floating nets (keramba) owned by residents.

2.3 Station III
This station is located in Ajibata District which is geographically located at points 20°39'33.01"N and 98°05'55.08"E. There were no floating cages or nets at this location and no aquatic plants such as water hyacinth were found. This location is a bit far from residential areas and hotel facilities and is used as a control area.

2.4 Primary Productivity Value Measurement
The method used in determining station points is "Purposive Random Sampling" using three observation stations. Sampling was carried out at three depths, namely surface, 3.5 meters deep, and 7 meters deep, with each observation point repeated twice. The division of this depth is based on the limit of light penetration in these waters is 7 meters.

Primary productivity measurements were carried out using the light and dark Winkler bottle method. At each depth soak one bottle of light Winkler and one bottle of dark Winkler. To get water samples from a depth of 3.5 m and 7 m used lamnot. Before the Winkler bottles are immersed, the initial DO of each depth is measured first. The soaking of the Winkler bottles starts at 10.00 WIB - 17.00 WIB, then the bottles are taken, then the final DO is measured and the primary productivity value is calculated.

2.5 Sampling
Water samples at each observation station were taken based on a depth of 0 m, 3.5 m, 7 m. For each depth, five repetitions were carried out. For water samples on the surface (0 m), taken using a 5 L bucket as much as 25 L. Poured into the plankton net. The remaining water in the bucket is taken and put into two bottles of film and 3 drops of Lugol are added. Then the film bottle is closed and labeled. Meanwhile, water sampling at a depth of 3.5 m and 7 m was carried out using a lamnot and the length of the lamnot rope was adjusted to the desired depth and then inserted into a body of water to obtain a water sample of 25 L.

2.6 Measurement of Physical Chemical Factors
Physical-chemical factors measured were temperature, light penetration, light intensity, hydrogen power (pH), dissolved oxygen, oxygen saturation, phytoplankton abundance, Biological Oxygen Demand (BOD), Phosphate and Nitrate content, Chemical Oxygen Demand (COD), Nitrate and phosphate.

a. Temperature (°C)
Temperature measurements both on the surface or at a depth of 3.5 m and 7 m were carried out using a mercury thermometer. For measuring water temperature from a depth of 3.5 m and 7 m, a lamnot was used to take water samples. The temperature of the water sample obtained was immediately measured.

b. Light Penetration (m)
Measured using secchi chips. Pieces of secchi are immersed in water so that they are not visible from the surface, then the length of the string is measured.

c. Light Intensity
Measurement of light intensity was carried out using a Lux meter. The value listed on the tool is the value of the intensity of light entering the body of water.

d. Power Hydrogen (pH)
The degree of acidity is measured using a pH meter, namely by inserting a pH meter into the water sample obtained from each depth to the number displayed on the constant device.

e. Oxygen saturation
Oxygen saturation is calculated using the formula for oxygen saturation level. For this reason, it is necessary to carry out oxygen concentration and water temperature from each depth.

f. Biological Oxygen Demand (BOD)
BOD measurement was also carried out using the Winkler method. However, water samples from each depth were first incubated at 20°C for five days. Then, the dissolved oxygen value was measured using the Winkler method. This value is considered as the final DO value. BOD levels will be known after subtracting the initial DO with the final DO. Attached work chart (Appendix E).

g. Chemical Oxygen Demand (COD)
COD measurements were carried out using the reflux method at the Research Center Laboratory of the University of North Sumatra, Medan. Attached work chart (Appendix F).

h. Nitrate and Phosphate levels
Measurement of levels of Nitrate and Phosphate using a spectrophotometer. Attached work chart (Appendix G and H)

Table 3.1. Tools and Units in the Measurement of Physical-Chemical Factors

<table>
<thead>
<tr>
<th>No.</th>
<th>Physical-Chemical Factor</th>
<th>Unit</th>
<th>Measuring instrument</th>
<th>The place Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Temperature</td>
<td>°C</td>
<td>Thermometer</td>
<td>In-situ</td>
</tr>
<tr>
<td>2</td>
<td>Light Penetration</td>
<td>m</td>
<td>Secchi chips</td>
<td>In-situ</td>
</tr>
<tr>
<td>3</td>
<td>Light intensity</td>
<td>Candella</td>
<td>Lux meter</td>
<td>In-situ</td>
</tr>
<tr>
<td>4</td>
<td>pH</td>
<td>-</td>
<td>PH meter</td>
<td>In-situ</td>
</tr>
<tr>
<td>5</td>
<td>DO</td>
<td>mg/l</td>
<td>Winkler Method</td>
<td>In-situ</td>
</tr>
<tr>
<td>6</td>
<td>BOD</td>
<td>mg/l</td>
<td>Winkler Method</td>
<td>In-situ</td>
</tr>
<tr>
<td>7</td>
<td>COD</td>
<td>mg/l</td>
<td>Reflux Method</td>
<td>Laboratory</td>
</tr>
<tr>
<td>8</td>
<td>Oxygen Saturation</td>
<td>%</td>
<td></td>
<td>In-situ</td>
</tr>
<tr>
<td>9</td>
<td>Nitrate Content</td>
<td>mg/l</td>
<td>Spectrophotometer</td>
<td>Laboratory</td>
</tr>
<tr>
<td>10</td>
<td>Phosphate Content</td>
<td>mg/l</td>
<td>Spectrophotometer</td>
<td>Laboratory</td>
</tr>
</tbody>
</table>

2.7 Identification
Water samples brought from the field were observed with a Sedgewich Rafter and observed under a microscope. The phytoplankton obtained were identified using the Edmondson (1963) identification reference book. Bold & Wynne (1985), Graham & Lee (2000).

2.8 Data analysis
The data obtained will be processed by calculating the level of oxygen saturation, the value of primary productivity of phytoplankton, phytoplankton chlorophyll a content, abundance of phytoplankton, F test and correlation analysis.

RESULTS AND DISCUSSIONS

3.1 Aquatic Primary Productivity
From the results of the study obtained the value of primary productivity of waters at each station as follows in Table 2.

Table 2. Value of Primary Water Productivity (mgC/m3/day) at Each Research Station in Parapat, Lake Toba

<table>
<thead>
<tr>
<th>Research Station</th>
<th>Productivity Primary Mg C/m3/day</th>
<th>Chlorophyll Abundance Mg/m3</th>
<th>Phytoplankton eng/l</th>
<th>DO Mg/l</th>
<th>BOD Mg/l</th>
<th>COD Mg/l</th>
<th>Nitrate Mg/l</th>
<th>Phosphate Mg/l</th>
<th>pH</th>
<th>Temperature °C</th>
<th>Saturat</th>
<th>Oxygen Saturation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I 0 m</td>
<td>300,288</td>
<td>2,673</td>
<td>396.12</td>
<td>6.8</td>
<td>1.5</td>
<td>8.5484</td>
<td>0.9077</td>
<td>0.2316</td>
<td>7.3</td>
<td>25</td>
<td>83.847</td>
<td>78.372</td>
</tr>
<tr>
<td>3.5 m</td>
<td>487,968</td>
<td>9.890</td>
<td>393.67</td>
<td>6.8</td>
<td>1.4</td>
<td>9.5444</td>
<td>1.0755</td>
<td>0.2773</td>
<td>7.8</td>
<td>24</td>
<td>83.847</td>
<td>78.372</td>
</tr>
<tr>
<td>7 m</td>
<td>122,608</td>
<td>2.673</td>
<td>193.83</td>
<td>6.8</td>
<td>1.2</td>
<td>8.7427</td>
<td>0.9677</td>
<td>0.2544</td>
<td>7.1</td>
<td>24</td>
<td>82.424</td>
<td>78.372</td>
</tr>
<tr>
<td>Average</td>
<td>300,288</td>
<td>5.078</td>
<td>269.87</td>
<td>6.8</td>
<td>1.36</td>
<td>8.9444</td>
<td>0.9823</td>
<td>0.2544</td>
<td>7.4</td>
<td>24.6</td>
<td>83.372</td>
<td>78.372</td>
</tr>
<tr>
<td>II 0 m</td>
<td>450.432</td>
<td>1.069</td>
<td>263.67</td>
<td>6.6</td>
<td>0.6</td>
<td>7.9520</td>
<td>0.8306</td>
<td>0.2666</td>
<td>7.2</td>
<td>23</td>
<td>78.758</td>
<td>78.372</td>
</tr>
<tr>
<td>3.5 m</td>
<td>375,360</td>
<td>3.742</td>
<td>1469.39</td>
<td>6.6</td>
<td>1.2</td>
<td>10.3376</td>
<td>1.4838</td>
<td>0.3856</td>
<td>7.2</td>
<td>24</td>
<td>80</td>
<td>78.372</td>
</tr>
<tr>
<td>7 m</td>
<td>225,216</td>
<td>4.009</td>
<td>2387.77</td>
<td>6.6</td>
<td>1.2</td>
<td>9.5427</td>
<td>0.9566</td>
<td>0.3010</td>
<td>7.2</td>
<td>24</td>
<td>80</td>
<td>78.372</td>
</tr>
<tr>
<td>Average</td>
<td>350,336</td>
<td>2.940</td>
<td>2387.77</td>
<td>6.6</td>
<td>1.2</td>
<td>9.2773</td>
<td>1.0016</td>
<td>0.3277</td>
<td>7.2</td>
<td>23.6</td>
<td>79.586</td>
<td>78.372</td>
</tr>
<tr>
<td>III 0 m</td>
<td>450.432</td>
<td>62.03</td>
<td>2755.09</td>
<td>7.2</td>
<td>1.2</td>
<td>5.9664</td>
<td>0.6656</td>
<td>0.3820</td>
<td>7.2</td>
<td>24</td>
<td>87.270</td>
<td>78.372</td>
</tr>
</tbody>
</table>
In Table 2, it can be seen that the highest average value of primary productivity is at station III of 500.480 mgC/m³/day and the lowest is at station I of 300.288 mgC/m³/day. The high value of primary productivity at station III is because this location is a location free from community activities so that the photosynthetic activity of phytoplankton is not disturbed. Likewise, other physical and chemical factors such as temperature, light intensity, pH, DO, oxygen saturation, as well as nitrate and phosphate nutrients are very supportive for the existence and activity of phytoplankton. According to Nyabakken (1992, hlm: 29), the decrease in primary productivity on the surface of the waters can be caused by the high intensity of sunlight causing damage to the chlorophyll of aquatic plants and will ultimately affect photosynthesis. The high value of primary productivity can also be influenced by the total abundance of a plankton, especially phytoplankton that can carry out photosynthesis. The average value of primary productivity at each depth is the highest at a depth of 3.5 meters at 563.04 mgC/m³/day and the lowest at a depth of 7 meters at 187.68 mgC/m³/day. The high value of PP at a depth of 3.5 meters can be caused by the quality of light obtained in optimal conditions so as not to damage plant chlorophyll and the photosynthesis process. However, in general, the primary productivity value of all research stations in Parapat, Lake Toba is relatively good where according to Jorgensen (1980) in Effendi (2003, pp: 231) that the average value of primary productivity in lake waters ranges from 50-300 mgC/m³/day.

### 3.2 Chlorophyll Concentration

From the data from the measurement of chlorophyll a concentration, the highest average value of chlorophyll a was obtained at station III of 38,045 mg/m³ and the lowest was at station II of 2,940 mg/m³. The high average value of chlorophyll a at station III corresponds to primary productivity, where phytoplankton activity is not disturbed. This location is free from community activities. Likewise, the measured value of physical and chemical factors is still very supportive for the existence of phytoplankton. According to Sverdrup et al., 1961, stated that chlorophyll a is one of the parameters that determine primary productivity in lakes where a high abundance of phytoplankton will produce more dissolved oxygen when compared to a low abundance of phytoplankton. Chlorophyll a is one of the parameters that determine primary productivity in waters. The distribution and high and low concentrations of chlorophyll a are closely related to the condition of a waters. The average value of chlorophyll a at each depth was the highest at a depth of 0 meters at 21.918 mg/l and the lowest at a depth of 3.5 meters at 4.811 mg/m³. The difference in the value of chlorophyll a from each station and depth may be caused by differences in the distribution of phytoplankton. According to Barus (2001, pp: 113), stated that the influence of plankton diversity in an aquatic ecosystem can lead to a high rate of photosynthesis resulting in high primary productivity.

### 3.3 Phytoplankton Abundance

From the results obtained that the highest average abundance of phytoplankton was obtained at station I of 2693.87 ind/l and the lowest was at station II of 2387.77 ind/l. However, the high and low values of phytoplankton abundance at the station did not show a clear relationship with chlorophyll.
a. This can be seen at station II, where the abundance of phytoplankton is high, but the value of chlorophyll a concentration is low. The difference in the abundance value of phytoplankton was obtained because of the far different activity between the three stations and besides that there was a species that had the highest and most dominant abundance, namely the Bacilariophyceae class of the Pediastrum genus. According to (Ferguson, 1956), that the chlorophyll content differs according to each phytoplankton, and even differs in each individual of the same species. Because the chlorophyll content depends on individual conditions. The amount of chlorophyll contained in plants also depends on the time and intensity of sunlight.

3.4 Water Chemical Physical Factor
From the results of measurements that have been carried out, the values of physical and chemical factors at each station are obtained as shown in Table 2.

3.4.1 DO (Dissolved Oxygen)
The highest average value from each station was obtained at station III of 7.2 and the lowest at station II of 6.6 mg/l as shown in Figure 4 below.

![Figure 4. Dissolved Oxygen Levels At Each Station](image)

The difference in dissolved oxygen values can be caused by the photosynthetic activity of phytoplankton. In addition, the presence of different organic matter at each station causes the oxygen consumption of bacteria and microorganisms to decompose these organic compounds is also different. According to Suin (2002) the oxygen dissolved in water comes from the air and the results of photosynthesis by plants in the water. Oxygen from the dissolved air enters the water due to direct diffusion and the movement of the water surface by the action of wind and turbulent currents.

The average DO value obtained based on the depth showed that the average DO value was 6.86 mg/l. Overall, dissolved oxygen levels at each station still support the existence of aquatic organisms. The value of dissolved oxygen in the waters should be in the range of 6-8 mg/l (Barus, 2004, page: 58). Next according to Sastrawijaya (1991), stated that life in water can survive if there is dissolved oxygen as much as 5 mg/l and depending also on the tolerance of the organism, the DO value obtained shows that the Parapat lake is still good.

3.4.2 BOD5 (Biological Oxygen Demand)
From the average value, the highest value was obtained at station I of 1.36 mg/l and the lowest at station II of 0.86 mg/l, as shown in the following figure.
BOD5 values obtained from each research location in principle indicate an indication of low levels of organic matter in the water. The BOD5 value is an indicator parameter of pollution, where the higher the number, the higher the level of pollution by organic substances and vice versa (Barus, 2001, page: 65). The average BOD5 value obtained based on the depth obtained was the highest at 7 meters at 1.33 mg/l and the lowest at 0 meters at 1.10 mg/l. From the BOD5 value, it shows that the water conditions are still good. The BOD5 value that varies at each depth is probably due to the movement of water causing agitation of water and contaminants. Indirectly, BOD5 is a description of organic matter levels, namely the amount of oxygen needed by aerobic microbes to oxidize organic matter into carbon dioxide and water. Effendi, 2003, pp: 120,125). The BOD5 value which is still considered good for a water is in the range of 0.1-5 mg/l.

3.4.3 COD (Chemically Oxygen Demand)

Based on the average value, it is known that the highest content is at station II of 9.2773 mg/l and the lowest is at station III of 6.4282 mg/l, as shown in the picture above. The difference in COD values obtained from the research results may be due to differences in activities that exist at each research station. According to Wardhana (1995, pp: 93), explained that in determining the COD value the amount of oxygen required for the oxidation reaction of the organic waste was equal to the amount of potassium bichromate. The more potassium bichromate used for the oxidation reaction, the more oxygen is needed.

The average COD value obtained based on the depth obtained was the highest at a depth of 3.5 meters at 8.8138 mg/l and the lowest at a depth of 0 meters at 7.3556 mg/l. According to Sastrawijaya (1991) in order to survive, the creatures that live in the waters are very dependent on the availability of dissolved oxygen in the waters. So, the high and low value of COD in waters is
related to the value of oxygen solubility, the oxygen content in the waters is very influential on primary productivity, especially phytoplankton that utilize dissolved oxygen as a basic material for the photosynthesis process in addition to the respiration process.

### 3.4.4 Phosphate and Nitrate Content

Based on the average value, it is known that the highest phosphate content is found at station II of 0.3277 mg/l and the lowest is at station III of 0.2090 mg/l, as shown in the following figure.

![Figure 7. Phosphate Content at Each Station](image)

![Figure 8. Nitrate Content at Each Station](image)

The rise and fall of the phosphate value can be caused by the movement of water so that the phosphate level is not evenly distributed at each station and its depth. According to Alaerts (1987, p: 234), stated that the increase in the concentration of phosphate (orthophosphate) was strongly influenced by the input of industrial, population and agricultural waste (rice fields).

The average value of phosphate obtained based on the depth obtained was the highest at a depth of 3.5 meters at 0.2923 mg/l and the lowest at 0 meters at 0.2367 mg/l. The water mass content tends to increase with increasing depth. Phosphate and nitrate are nutrients needed by phytoplankton and other aquatic plants for their growth.


Based on the average value, it is known that the highest nitrate content is at station II of 1.0916 mg/l and the lowest is at station III of 0.7511 mg/l. From the nitrate levels obtained, it shows that the source of nutrients in Lake Toba resulting from community activities is relatively low. However, the mixing due to water movement causes the nitrate level at each station to not be too high. According to Mackentum, (1969) in Haerlina (1987, pp: 8), states that the optimal nitrate level for phytoplankton growth is 3.9-15.5 mg/l and for optimal growth required phosphate concentration (orthophosphate) in the range of 0.27 mg/l-5.51 mg/l.

The average value of nitrate obtained based on the depth obtained is the highest at a depth of 3.5 meters at 1.0965 mg/l and the lowest at a depth of 0 meters at 0.7899. Nitrates are nutrients...
needed by plants to grow and develop. The presence of nitrate is strongly influenced by waste that can come from industry, explosives, protechnics and fertilization. Naturally, nitrate levels can be very high in groundwater in areas that are given nitrate/nitrogen fertilizers. (Aaerts, 1987, pp: 159,161)

3.4.5 pH (Potential Hydrogen)

From the average value, the highest pH value was obtained at station III of 7.53 and the lowest at station II of 7.2 as shown in Figure 5 below.

![Figure 9. pH Range At Each Station](image)

From the average pH value obtained, it can be described that the pH in Lake Toba is in a neutral condition. This means that it is still good and supports the life of aquatic biota, especially phytoplankton. According to Hawkes (1979) in Sinambela (1994, p: 33), states that life in water can still survive if the waters have a pH range of 5-9. From the data obtained, it can be illustrated that the pH in Parapat, Lake Toba is in a neutral condition. Where the pH is still good and supports the life of aquatic biota, especially phytoplankton.

The average pH value obtained is based on depth, the highest pH at a depth of 3.5 meters is 7.5 and the lowest is at a depth of 0 meters at 7.27. The difference in pH at each depth can be caused by the presence of high lime content which can cause a significant increase in pH values in an ecosystem. According to Ginting (2002, pp: 8) The occurrence of differences in chemical composition at each station is influenced by an increase in the chemical composition of the bottom substrate of the waters.

3.4.6 Temperature (°C)

The highest average temperature value was obtained at station I of 24.66 °C and the lowest at station II of 23.66 °C as shown in the following figure:

![Figure 10. Temperature range at each station](image)

This situation can be caused by unstable weather conditions caused by wind, waves. According to Barus (2004, pp.: 44-45), stated that the temperature pattern of aquatic ecosystems is influenced by various factors such as light intensity, heat exchange between water and the surrounding air and is also influenced by the canopy factor (vegetation cover) of trees growing on the edge.
The average temperature value obtained based on the depth obtained the highest average temperature at a depth of 3.5 meters at 24.30 °C and the lowest at a depth of 7 meters at 23.60 °C. The difference in water temperature between the surface and the depth is not too far. The temperature range in Lake Toba does not fluctuate or is relatively constant because it does not experience high changes. The water temperature in Lake Toba is generally homogeneous which fluctuates vertically according to the depth of the water layer. From the results of the study it was found that the value of water temperature in the surface layer of Lake Toba was not much different when compared to temperatures at various depths of the lake (at a depth of 200-500 m), the difference was only 1 °C (Barus, 2004, pp: 107). According to Brower, et al. (1990, pp: 549), the optimal temperature range for phytoplankton growth is between 20 °C-25 °C. So the temperature range obtained from these waters is still in the range that supports the growth of phytoplankton in Parapat, Lake Toba.

3.4.7 Oxygen saturation
The highest average value was obtained at station III of 86.819% and the lowest was at station II of 79.586 as shown in the following figure.

This is because water bodies have a large enough source of oxygen that comes from the photosynthesis of phytoplankton. According to Schwrobel (1987) in Barus (1996, p:11 .), the value of dissolved oxygen in waters experiences daily and seasonal fluctuations which are strongly influenced by changes in temperature and photosynthetic activity of plants that produce O2.

The average value of oxygen saturation obtained based on the depth obtained is the highest at a depth of 3.5 meters at 83.71% and the lowest at a depth of 7 meters at 82.78%. The difference in oxygen saturation is caused by the presence of organic compounds in the form of household waste, hotel waste, oil spills and others. At the research station where the use of oxygen by microorganisms to decompose these organic compounds is also different. However, from the oxygen saturation value obtained, it shows the level of pollution in Parapat, Lake Toba is still relatively low. According to Ginting (2002, pp.: 6-7), organic waste will cause the use of oxygen by aquatic biota to increase, namely to decompose the waste, so that there is also an increase in oxygen saturation which will indicate an oxygen deficit at that location. The dissolved oxygen deficit can be caused by the non-optimal rate of photosynthesis, the slow movement of water, causing the absorption of oxygen from the air into the water not to take place properly, thereby reducing the dissolved oxygen level in the water.

3.4.8 Light Penetration and Intensity
From the data obtained, the penetration of light at all research stations is 7 meters. This shows that the clarity of water bodies between the three stations is still relatively the same. The value of light penetration in a body of water is influenced by the substances suspended in the water.

According to Nybakken (1992, hlm: 62) that the presence of suspended substances in the waters will cause turbidity in the waters and this turbidity will affect the ecology in terms of a
striking decrease in light penetration. According to Odum (1998, pp: 370), that the penetration of light is often blocked by dissolved substances in the water thus limiting the photosynthetic zone.

From the measurement results, it was found that the highest light intensity was 976 cd at station I. While the lowest light intensity was 208 cd at station III. This difference occurs due to the difference in measurement time.

Nyabakken (1992, p: 61) suggests that changes in light on the surface vary regularly on a daily basis associated with the seasons. The decrease in light intensity and absorption will decrease because it is influenced by depth. The amount of sunlight that enters the water varies depending on the intensity of the light, the amount of reflection on the surface, the angle of incidence and the transparency of the water.

3.5 f. test
The following is a table of variance analysis, from the analysis that has been carried out on the primary productivity values found in all stations and all depths.

Table 3. Table of Test Results for Primary Productivity between Stations and also between Depths

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Total Value</th>
<th>Level Free</th>
<th>Mark average</th>
<th>F</th>
<th>Sig.</th>
<th>F Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Stations</td>
<td>6.571</td>
<td>7</td>
<td>0.939</td>
<td>1.729</td>
<td>0.208</td>
<td>3.11</td>
</tr>
<tr>
<td>Error</td>
<td>5.429</td>
<td>10</td>
<td>0.543</td>
<td></td>
<td></td>
<td>5.06</td>
</tr>
<tr>
<td>Total</td>
<td>12,000</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Depth</td>
<td>6.571</td>
<td>7</td>
<td>0.939</td>
<td>1.729</td>
<td>0.208</td>
<td>3.11</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>5.06</td>
</tr>
<tr>
<td>Total</td>
<td>12,000</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on the table above because F = 1.729 then F < 5.06 at the 0.05 level so that the rejection area used is to accept Ho. Where Ho is U1 = U2 = U3 or the average difference is not significant in the meaning of the word the same both between stations and between depths. so no further significant tests are needed.

From table 3 we can see that the F statistic is smaller than the F table value. Where the F statistic price obtained from the calculation results is 1.729 while the F table price is 3.11 at the 0.05 level and 5.06 at the 0.01 level, so it can be concluded that the rejection area used is Ho = U1 = U2 = U3 or the mean not significant. In other words, there is no significant difference between the primary productivity values between stations and depths, or it can be said that according to this statistical test, productivity between stations and depths is relatively the same or not much different.

3.6 Correlation Analysis
To determine the relationship between physical and chemical factors with the primary productivity of waters from each station, the values of these two variables were correlated using Pearson correlation analysis which was carried out computerized using SPSS 10.00. The results of the correlation of the two variables are as follows.

Table 4. Correlation Value Between Physical and Chemical Factors in Parapat, Lake Toba Waters with Primary Productivity of Waters from Each Research Station

<table>
<thead>
<tr>
<th>Correlation</th>
<th>chlorophyll</th>
<th>Keleng/l</th>
<th>oC</th>
<th>pH</th>
<th>DO</th>
<th>BOD</th>
<th>Kejo_O2</th>
<th>COD</th>
<th>Nitrate</th>
<th>Phosphate</th>
</tr>
</thead>
</table>

From Table 4, it can be seen that the value of physical and chemical factors is not very strongly correlated with primary productivity. From the results of the correlation analysis, it was found that the primary productivity correlated (+) to the abundance of phytoplankton, pH, temperature, DO, oxygen saturation. Meanwhile, chlorophyll, BOD, COD, nitrate, phosphate correlated (-) with primary productivity.

According to Sugiyono (2005), the correlation coefficient can be divided into several levels as in the table above.

<table>
<thead>
<tr>
<th>intervalcoefficient</th>
<th>Level</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 – 0.199</td>
<td>Very low</td>
<td></td>
</tr>
<tr>
<td>0.20 – 0.399</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>0.40 – 0.599</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>0.60 – 0.799</td>
<td>Strong</td>
<td></td>
</tr>
<tr>
<td>0.80 – 1.000</td>
<td>Very strong</td>
<td></td>
</tr>
</tbody>
</table>

From the coefficient interval value, the primary productivity that has a very low correlation is temperature, while the one with a moderate correlation to primary productivity is the abundance of phytoplankton.

CONCLUSION

From the results obtained it can be concluded:
1. From the isolation carried out on the root nodules of Pueraria javanica, 10 isolates of Rhizobium were obtained which have the ability to form root nodules on these plants. The isolate that formed the most nodules was M3 isolate obtained from the Marihat Oil Palm Plantation.
2. The ten Rhizobium isolates obtained had a more stable viability on the carrier medium of oil palm empty fruit bunches.

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REFERENCES


Faculty.
Haerlina, E. 1987. Composition and Daily Vertical Distribution of Phytoplankton During Day and Night in Bojonegoro Coastal Waters, Banten Bay. Faculty of Fisheries, Bogor: IPB
Main Library.