The dynamic structure of phytoplankton community in Segara Anak Lake: a volcanic lake in Mount Rinjani National Park

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Abstract. Segara Anak is a volcanic lake located in the Mount Rinjani National Park, West Nusa Tenggara, Indonesia. It covers an area of ± 11.3 km² with a maximum depth of 230 m at 2010 m.a.s.l. Segara Anak one of tourism object around Rinjani Mountain. The purpose of this research was to study the phytoplankton community structure and physical and nutritional factors correlation in Segara Anak spatially and temporally. The sampling technique used was a purposive sampling method. The samples were taken at five stations with an increasing depth of 1 m, 5 m, and 10 m respectively. The sample collection was started from October to December 2017. The data were analyzed using One-way ANOVA, Kruskal Wallis, Cluster Analysis and Principal Component Analysis. We identified 19 phytoplankton genera with 4 classes. The phytoplankton structure, nutrient, and physical factors are significantly different in spatial depth and temporal sampling. The abundance of phytoplankton in Segara Anak is dominated by the Cyanophyceae class.

1. Introduction

Indonesia is one of the countries that has the most volcanoes. Some of them have lakes which are resulted from a large eruption process of the volcanoes. The lake is called caldera lake. Segara Anak is one of the highest caldera lakes in Indonesia. This lake was formed by the super-eruption of Mount Rinjani in A.D 1257 [1]. Segara Anak is a popular tourism object in the mount Rinjani National Park (TNGR). The lake is used as a camping area, fishing and sources of fresh water for tourists. In the last five years, the average number of climbers in Mount Rinjani was 49,765 people year⁻¹ [2].

Segara Anak is also classified as a volcanic lake. The volcanic activity from Gunung Baru Jari such as hydrothermal activity and larval during the eruption affects the waters of Segara Anak [1,3]. Six eruptions have been recorded on Mount Baru Jari in 1994,1995,1996, 2009 and 2015 [2]. The eruption's effects physical and chemical factors of water such as an increase in the water temperature, decreasing in pH to become more acidic, and some changes in chemical compounds such as iron, calcium and silicon [4].

The volcanic and anthropogenic activity around Segara Anak has a potential hazard which may affect the physical and chemical condition of the lake. These inputs can influence water quality and directly affect the aquatic organism. Phytoplankton is one of the aquatic organisms which able to
respond to the change of water environment [5,6]. The community structure and biomass of phytoplankton might be altered due to the availability of the nutrient in the water [7-8]. The availability of nutrients such as nitrogen, phosphor, and silica become the main limiting factor for phytoplankton. Those elements can affect the growth of phytoplankton [9-10].

Phytoplankton has an important ecological role in the water ecosystem. They act as the primary producer of the food chain in the water. Through photosynthesis, phytoplankton can control the rate of primer productivity [11-12]. The primer productivity is the main requirement to study the structure and the function of the water ecosystem. The amount of primer productivity depends on some factors including the abundance of phytoplankton, chlorophyll a, physical and chemical factors [13]. Based on those matters, we provided the data about the community structure of phytoplankton and the effect of environmental factors on phytoplankton at Segara Anak Lake

2. Methods

2.1. Study site description

This research was carried out from October to December 2017 at Segara Anak Lake, Lombok Island, West Nusa Tenggara. Segara Anak is located on the 2010 m.a.s.l and covers an area of ± 11.3 km² with the maximum depth 230 m [14]. This lake is located in Mount Rinjani National Park (TNGR) with 8°25’00” southern latitude – 116°28’00” east longitude (Figure 1). The sampling used Purposive method sampling. The sampling was taken spatially and temporally. The sampling was spatially taken based on the station (Station I, II, III, IV, and V) and in different depths (1 m, 5 m and 10 m) whereas, the sampling was taken temporally on October, November and December.

Figure 1. Depicting the map of Segara Anak Lake and the sampling points.
2.2. Phytoplankton Sampling

The water sampling of phytoplankton was taken by using Van Dorn Water Sampler with a capacity of 1 L. The water as the sample was taken 50 L in each depth of 1 m, 5 m, and 10 m, and then it was filtered by using phytoplankton net. Moreover, a filtered water sample was filled into the bottle with a capacity of 100 mL and it was preserved by using lugol 0.5 mL [15]. The calculation and identification of phytoplankton were carried out at the laboratory of productivity and aquatic environments of Bogor Agricultural University. We used Zeiss Primo Star microscope with the zoom 10 x 10 and the phytoplankton identification was referred to The Marine and Freshwater Plankton from Davis [16]. The phytoplankton abundance was calculated by using the sweeping census method Sedgwick Rafter Cell (SRC) with the formula based on [17]:

\[
N = n \times \frac{V_t}{V_{SRC}} \times \frac{A_{SRC}}{A_a} \times \frac{1}{V_d}
\]

Where:
- \( N \): the abundance of plankton (cell L\(^{-1}\))
- \( n \): the number of observed organisms (cell)
- \( V_t \): the volume of filtered water (mL)
- \( V_{SRC} \): the volume of one SRC (1 mL)
- \( A_{SRC} \): the width of SRC section (mm)
- \( A_a \): the width of observation (mm)
- \( V_d \): the volume of filtered water (L)

2.3. The sampling of Physical Factor

The measurement of a physical factor was conducted by in situ started from 9.00 WITA until the finish. The detail of the measured physical parameter and the equipment used to measure those parameters were presented below (Table 1).

| Parameter                  | Unit   | Equipment                              |
|----------------------------|--------|----------------------------------------|
| Light Intensity            | LUX    | Lux meter Lutron lx-101a                |
| Water Transparency         | m      | Secchi disk                            |
| Water Temperature          | °C     | Thermometer Lutron PDO 520             |
| pH                         |        | pH meter ATC Digital Tester            |
| Dissolved Oxygen (DO)      | mg L\(^{-1}\) | DO meter Lutron PDO 520               |

The sunlight intensity distribution at a depth of 1 m, 5 m and 10 m was calculated according to the law of Beer-Lambert (18) with the formula as follows:

\[
I_z = I_0 e^{k \gamma Z}
\]

Where:
- \( I_z \): Light intensity in the depth
- \( I_0 \): Light intensity at the surface
- \( e^{k \gamma Z} \): the dimming coefficient in the depth
2.4. The Sampling of Nutrient
The water sample for the nutrient analysis was collected by using Van Dorn Water Sampler at each station with the depth of level 1 m, 5 m, and 10 m. We measured several parameters such as Dissolved Inorganic Nitrogen (DIN), Dissolved Inorganic Phosphate (DIP), and silica by using spectrophotometric analysis method [17]. The analysis was conducted at the laboratory of environmental productivity and aquatic Bogor Agricultural University.

2.5. The Analysis of Chlorophyll a
The 500 mL water sample for the chlorophyll-a analysis was collected and filtered by using a filter bottle and Millipore membrane. The result of filtering was the chlorophyll-a in the Millipore membrane and then it was preserved by using 1 mL MgCO$_3$. Furthermore, the chlorophyll-a concentration was measured by using spectrophotometer accounted with equation according to APHA ([6], as follow:

$$\text{Chlorophyll a} = \frac{26.7 \times (664_b - 665_a) \times V_1}{V_2 \times I}$$

(3)

Where :
V$_1$ : Extracted Volume
V$_2$ : Volume of sample
664$_b$ : Abs. at 664 nm-abs. at 750 nm before acidification.
665$_a$ : Abs. at 664 nm-abs. at 750 nm after acidification
I : the length of the cuvette

2.6. Data Analysis
The differences in environmental factors (chemical and physical) and biotics variables (abundance of phytoplankton and chlorophyll a) were analysed by One Way ANOVA and Kruskal Wallis test using SPSS Version 21. The testing has conducted the difference of each variable such as physicals factor, nutrient, and the abundance of phytoplankton spatially and temporally, whereas for the grouping of the station and the relation among the variables was used Cluster Analysis and Principal Component Analysis (PCA).

3. Results and Discussion
3.1. Physical Factors: Temperature
Temperature affects certain activities of phytoplankton. The increase and decrease of the temperature control the physiology of phytoplankton. The measurement result of the water temperature of Segara Anak Lake was various. The result of the statistical analysis showed the parameter of temperature was different between the station and the depth (ANOVA, $\rho$â‰¥0.05). The additional testing (Tukey, $\rho$â‰¥0.05) showed the difference among the station I and II with the station III, IV, and V. whereas, the result of additional testing (Tukey, $\rho$â‰¥0.05) every depth showed the difference. The average water temperature at the station I was higher than the others, while the average water temperature at a depth of 1 m was higher than the depth of 5 m and 10 m (Figure 2a).

The temperature in Segara Anak Lake was higher than the temperature in the other caldera lakes. Cocquyt et al. [19] reported the temperature at Kyaninga lake was about 22.80-23.10 °C. Degefu et al. [20] also reported the temperature at Wonchi lake which was about 14.5-17.5 °C. However, the temperature in Segara Anak was below the optimum temperature of phytoplankton growth. The optimum temperature for phytoplankton growth is 27-30 °C [21]. The temperature conditions in Segara Anak were also much lower when compared to the water temperature in other tropical lakes in the lowlands. Sutrisno and Hamdani [22] reported that temperatures in Lake Maninjau ranged from 28-32°C. Wijaya and Hariyanti [23] also added that the temperature at Lake Rawa Pening ranged from 27-
28 ºC. In addition to the two lakes, based on the report Sugianto et al. [24] the temperature in Lake Talaga range from 29-31ºC. The geographical position of the lake in the highlands can be one of the reasons for the low temperature in the Segara Anak lake compared to other lakes in the low tropical region.

3.2. Physical Factors: pH

The neutral pH is an optimum pH for all aquatic organisms including plankton. The range of aquatic pH is around >6.0-8.5 and it is the ideal pH for the living of phytoplankton [25]. The result of pH analysis at Segara Anak lake among the stations and the depths was not significantly different (ANOVA, \(\rho \geq 0.05\)) (Figure 3a) while, based on the period of sampling, the value of pH was significantly different (Figure 3b).

![Figure 2](image_url)

**Figure 2.** Graphics of average temperature among stations and the depths (a), stations and time (b).

![Figure 3](image_url)

**Figure 3.** The Graphic of pH average: between station and depth (a), station and time (b).
The result showed that pH at Segara Anak lake was acidic. The value of the pH was lower than the value of pH at the other caldera lakes which were usually neutral. Satyanayar et al. [26] reported that pH at Lonar Lake in India was around 9.85-10.1, while at the other caldera lakes such as at Kawah Ijen, the value of the pH was very high. Besides that, pH at the Kawah Ijen had acidic level 0.3 [27]. The condition of acid pH at Segara Anak Lake was caused by the increase of dioxide sulfur magma as the effect of the eruption process of Gunung Baru Jari [4].

3.3. Physical Factors: DO

DO have an important role in the aquatic ecosystem. The oxidation process and the reduction of organic material in the water needs optimum DO level. The value of DO at Segara Anak Lake was around 5.2 – 7.3 mg L⁻¹ (Figure 4a). The content of DO at Segara Anak Lake was higher than the other caldera lakes. The content of DO at the surface of Toba Lake was around 2.16-5.12 mg L⁻¹ (28). The value of DO was decreased based on the depth of the sampling. The average of DO at the surface 1 m of the lake was higher than in the depth of 5 m and 10 m. The result of statistical analysis of DO among the stations was not significantly different (ANOVA, ρ≥0.05), but it was significantly different based on the depth (ANOVA, ρ≤0.05) (Figure 4a). Further testing among the depths showed the difference of the depths between 1 m and 10 m (Tukey, ρ≤0.05). Based on the sampling period, the value of DO was significantly different (ANOVA, ρ≤0.05).

3.4. Physical Factors: Water Transparency and Light intensity

Water turbidity represents the amount of material that is suspended in the waters. Water transparency in Segara Anak Lake was about 2.561-3. 331 m of all station with results showing that station I had the lowest transparency and station V had the highest transparency compared to other stations.

Light is very important to the photosynthesis process of phytoplankton. Phytoplankton absorbed the light with the specific length of the wave. The amount of light that reached the water decided to the rate of photosynthesis of phytoplankton. Generally, light intensity decreased or increased in depth depending on the organic material/non-organic material in the water.

The result of statistical analysis showed the average of the light intensity at Segara Anak which was not different with the average of the light intensity in the other stations (ANOVA, ρ≥0.05) but they were a significant difference among the depths (ANOVA, ρ≤0.05). The measurement results of light intensity showed that the light intensity at Segara Anak Lake was decreased with the increase of the
depth. The distance of the stations which was not too far caused the similar light spread among the stations (Figure 5a). Light also was significantly decreased (ANOVA, \( \rho \leq 0.05 \)) in every month. The decrease of Light intensity in November and December (Figure 5b). The light had a strong relationship with the season. According to the data of the Indonesian Agency for Meteorology, Climatology, and Geophysical (BMKG) [29], the season on November and December around the Mount Rinjani entered the rainy season with the high intensity.

![Figure 5](image)

**Figure 5.** Graphic of the average of light intensity among the stations and depths (a), stations and time (b).

### 3.5. Nutrient

A nutrient is a chemical element needed by phytoplankton for their growth. The number of nutrient ratios in the water determines the composition and the abundance of phytoplankton. In addition to typical physical factors, the nutrient content in volcanic lakes also has distinctive characteristics. Generally, the nutrient content in volcanic lakes is derived from volcanic activity and weathering of rocks around the lake compared to anthropogenic activities so that generally the nutrient content is classified as low [30]-[31].

The low nutrient in Segara Anak showed in Table 2. The concentration of DIN and DIP was not significantly different among the stations and the depths (Kruskal Wallis, \( \rho \geq 0.05 \)). The concentration of silica was not significantly different based on the station (ANOVA \( \rho \geq 0.05 \)), but it was significantly different based on the depth (ANOVA, \( \rho \leq 0.05 \)). Silica had the highest concentration among the other nutrients. The high concentration of silica at Segara Anak Lake was caused by the rocks or sediments. Rachmat et al. [3] reported that silica at Segara Anak Lake was the easiest compound to be found after the aluminium oxide.
Table 2. The Result of the Measurement of Nutrient Based on the Station and the Depth.

| Station | The Depth of 1 m | The Depth of 5 m | The Depth of 10 m | Ratio N:P |
|---------|-----------------|-----------------|-----------------|----------|
|         | DIN (mg L⁻¹)    | DIP (mg L⁻¹)    | Silica (mg L⁻¹) | DIN (mg L⁻¹) | DIP (mg L⁻¹) | Silica (mg L⁻¹) | DIN (mg L⁻¹) | DIP (mg L⁻¹) | Silica (mg L⁻¹) | N:P |
| I       | 0.260           | 0.045           | 2.079           | 0.120       | 0.041       | 1.607           | 0.075       | 0.048       | 1.283           | 3:1 |
| II      | 0.151           | 0.045           | 2.022           | 0.104       | 0.040       | 1.528           | 0.122       | 0.041       | 1.413           | 3:1 |
| III     | 0.092           | 0.050           | 1.898           | 0.164       | 0.042       | 1.419           | 0.146       | 0.031       | 1.278           | 3:1 |
| IV      | 0.107           | 0.048           | 1.910           | 0.590       | 0.041       | 1.357           | 0.167       | 0.042       | 1.448           | 6:1 |
| V       | 0.125           | 0.039           | 1.768           | 0.081       | 0.047       | 1.313           | 0.122       | 0.027       | 1.555           | 2:1 |

The concentration of DIP and silica showed a significant difference of the periods (Kruskal Wallis, \( \rho \leq 0.05 \)). The concentration of both of the nutrients decreased in November and December (Table 3). It was totally different from the concentration of DIN which was not different in the months (Kruskal Wallis, \( \rho \leq 0.05 \)).

Table 3. The result of the measurement of nutrient based on the station and month.

| Station | October | November | December | Ratio N:P |
|---------|---------|----------|----------|----------|
|         | DIN (mg L⁻¹) | DIP (mg L⁻¹) | Silica (mg L⁻¹) | DIN (mg L⁻¹) | DIP (mg L⁻¹) | Silica (mg L⁻¹) | DIN (mg L⁻¹) | DIP (mg L⁻¹) | Silica (mg L⁻¹) | N:P |
| I       | 0.180   | 0.061   | 2.857   | 0.068   | 0.040   | 1.619   | 0.261   | 0.044   | 1.433   | 3:1 |
| II      | 0.119   | 0.048   | 3.045   | 0.066   | 0.051   | 1.335   | 0.125   | 0.031   | 1.632   | 2:1 |
| III     | 0.072   | 0.058   | 2.922   | 0.066   | 0.046   | 1.331   | 0.209   | 0.033   | 1.391   | 2:1 |
| IV      | 0.072   | 0.054   | 2.697   | 0.399   | 0.054   | 1.370   | 0.187   | 0.031   | 1.510   | 4:1 |
| V       | 0.180   | 0.044   | 2.402   | 0.066   | 0.047   | 1.366   | 0.134   | 0.026   | 1.513   | 3:1 |

The concentration of DIN and DIP in Segara Anak lake Spatially and temporally lower than other tropical lakes. Sutrisno and Hamdani [32] reported that the average total DIN and phosphate in Lake Maninjau were 0.366–7.429 mg L⁻¹ and 0.020–0.134 mg L⁻¹, respectively. Kusumawati et al. [33] also added the content of DIN and phosphate in Lake Telaga Merdada respectively 1.02–1.28 mg L⁻¹ and 1.37–1.74 mg L⁻¹. In addition, the ratio of N:P in the research was under the average of 16:1 (Table 4). Ratio 16:1 was the optimal ratio for phytoplankton which was appropriate with Redfield ratio. The ratio which was under 16:1 indicated nitrogen became the limiting nutrient for the growth of phytoplankton, whereas the ratio above 16:1 indicated phosphate as the limiting factor [34]. In this research, all stations indicated nitrogen as the limiting factor.

3.6. Chlorophyll a

The concentration of chlorophyll-a in this study was spatially and temporally various Chlorophyll measurement results indicate phytoplankton biomass at the station I was higher than other stations and at some stations, the phytoplankton biomass at the surface is higher than the deeper parts (Figure 6). The content of chlorophyll-a was significantly different among stations and depths (ANOVA, \( \rho \leq 0.05 \)). The highest average content of chlorophyll a was at the station I which was \( 5.37 \pm 0.68 \mu g L^{-1} \) while the lowest was at the station IV which was \( 2.31 \pm 0.99 \mu g L^{-1} \).
Table 4. The composition and abundance of phytoplankton based on general and the class.

| Class/Species       | Abundance (cell L$^{-1}$) |
|---------------------|---------------------------|
| **Bacillariophyceae** |                           |
| 1 Amphora sp        | 20367.96 ± 921.2097        |
| 2 Cyclotella sp     | 86650.8 ± 3350.019         |
| 3 Fragiliria sp     | 34590.75 ± 1156.303        |
| 4 Nitzschia sp1     | 29991.53 ± 1608.162        |
| 5 Navicula sp       | 19672.28 ± 776.8971        |
| 6 Nitzschia sp2     | 33663.18 ± 813.2639        |
| 7 Rhopalodia sp     | 28406.93 ± 1128.502        |
| 8 Cymbella sp       | 20870.4 ± 728.7867         |
| 9 Nitzschia sp2     | 22532.3 ± 675.4268         |
| **Cyanophyceae**    |                           |
| 10 Anabaena sp      | 29569917.05 ± 286083.5     |
| 11 Lyngbya sp       | 73046.4 ± 5227.182         |
| 12 Oscillatoria sp  | 69413.4 ± 5894.819         |
| **Chlorophyceae**   |                           |
| 13 Closteriopsis sp | 118806.68 ± 3423.255       |
| 14 Treubaria sp     | 14454.68 ± 597.5806        |
| 15 Ankistrodesmus sp| 16232.53 ± 689.0536        |
| 16 Stigeoclonium sp | 9507.62 ± 1214.197         |
| 17 Staurastrum sp   | 33353.99 ± 2714.787        |
| 18 Cosmarium sp     | 785615.96 ± 15397.59       |
| **Dinophyceae**     |                           |
| 19 Peridinium sp    | 43608 ± 5023.14            |

Figure 6. The average of Chlorophyll a based the stations and the depths.
The concentration of chlorophyll-a temporally was not significantly different (ANOVA, \( \rho \geq 0.05 \)). The decrease of chlorophyll concentration occurred in November and December. The average of the highest content of chlorophyll a was on October, which was \( 5.55 \pm 1.06 \mu g \text{ L}^{-1} \) whereas the lowest average was on December \( 2.90 \pm 0.22 \mu g \text{ L}^{-1} \) (Figure 7). This is consistent with the physical and chemical factors which are also the lowest in November and December.

![Figure 7](image_url)

**Figure 7.** The average of Chlorophyll a based the stations and the month.

### 3.7. The composition and the abundance of phytoplankton

We identified 19 genera of phytoplankton which were divided into four classes. The class consisted of Bacillariophyceae, Cyanophyceae, Chlorophyceae, and Dinophyceae. Bacillariophyceae was found with the highest number of genera compared to other classes, it consists of 9 genera. The result of this research found that the number of phytoplankton genera was less than the results of previous research in the same lake that contained 39 genera [35].

The abundance of phytoplankton showed insignificant difference among the stations (ANOVA, \( \rho \geq 0.05 \)), but it was significantly different based on the depth (ANOVA, \( \rho \leq 0.05 \)). The result of further testing showed the significant difference among 1 m depth with 5 m and 1 m with 10 m, while between 5 m and 10 m depths were not significantly different (Tukey, \( \rho \leq 0.05 \)). These results indicated that the depth level for an abundance of phytoplankton in this study was divided into two levels. The first level at a depth of 1 m and second level at a depth of 5 m and 10 m. The highest abundance of phytoplankton was at 1 m depth, which was \( 1 797 \ 318 \pm 15 \ 852 \text{ cells L}^{-1} \), while the lowest abundance was at 10 m depth, which was \( 1 363 \ 411 \pm 26 \ 452.15 \text{ cells L}^{-1} \) (Figure 8).

![Figure 8](image_url)

**Figure 8.** The average abundance of phytoplankton based on the stations and the depths.
Based on the sampling period, the abundance of phytoplankton was significantly different (ANOVA, \( \rho \leq 0.05 \)). The Tukey test showed the difference in October, November and December (Tukey, \( \rho \leq 0.05 \)). Whereas, the abundance of phytoplankton between November and December was not significantly different (Tukey, \( \rho \leq 0.05 \)) (Figure 9).

![Figure 9](image)

**Figure 9.** The average abundance of phytoplankton based on the stations and the month.

The phytoplankton of Segara Anak Lake was dominated by the Cyanophyceae in all stations. This class has the highest average abundance in all stations, which was \( 7 \, 624 \, 498 \pm 215 \, 849 \) while the phytoplankton class which had the lowest abundance was the Charophyceae with an average abundance at all sampling points only reached \( 27 \, 537 \pm 2 \, 714 \) cells L\(^{-1}\). The dominance of phytoplankton abundance in Segara Anak Lake was changed if this was compared to previous research. Arianto et al. [35] reported that phytoplankton abundance in 2014 was dominated by Bacillariophyceae class.

The change of phytoplankton's composition in Segara Anak Lake was caused by several things. Physical factors especially pH became a restraint factor for most phytoplankton. For example, in the Bacillariophyceae, metabolic processes such as shell formation were disrupted at low pH. This explained the condition in Segara Anak Lake which had high silica, however, the abundance of Bacillariophyceae was actually lower. The class that was tolerant of low pH such as Cyanophyceae was developed very well and became the dominant class. The availability of certain proteins which had an important role in acid stress such as Anabaena-GG-SK A7 in some species of the Cyanophyceae class made this species was resistible to acidic pH even until reached pH 4 [36].

Nutrients were also important in phytoplankton composition at Segara Anak Lake. The N: P ratio in this research averaged below 10: 1. Under this condition, nitrogen was the main limiting factor and Cyanophyceae was dominant class [37,38]. There was no better class than those which could not compete in nitrogen intensity, while the Cyanophyceae was more competent because of the ability of the species used to fix nitrogen from free air.

### 3.8. The Relation of Physicals Factor and Nutrient to the Abundance of Phytoplankton

The result of Cluster Analysis showed two groups of the station which had physicals character factor, nutrient, chlorophyll a, and the abundance of the same phytoplankton. The first group consisted of the station I and II, whereas the second group consisted of station III, IV, and V (Figure 10). The grouping occurred because of the different aquatic environmental characteristic at the station. The station I and II were the closest station with the activity of Mount Baru Jari and there were many camps there, whereas, at station III, IV, and V were far enough from the camping location and from the activity of Mount Baru Jari.
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![Figure 10. Cluster Analysis environmental factors and phytoplankton abundance.](image1)

The analysis of PCA also showed that the position of the station I and II with station III, IV, and V was far enough. It reinforced that the environmental characteristics of the two groups of the station were different. PCA result also showed that station I and II had a high abundance of phytoplankton and also had better water quality for phytoplankton’s growth if compared to station III, IV and V (Figure 11).

![Figure 11. Biplot diagram of the relation between phytoplankton and environmental factor.](image2)
Based on the class, the abundance of phytoplankton in PCA analysis showed a typical character. The abundance of the Cyanophyceae class at the station I had a close correlation with chlorophyll a, temperature, and DIP. DIP concentration and temperature at the station I had a major influence on the growth of Cyanophyceae. That was absolutely different from the parameter of pH, DO, and light that did not have a correlation with the abundance of Cyanophyceae. The high tolerance in this class, especially to pH, caused there was a dominance of the class even though the pH in Segara Anak Lake was low. The abundance of Bacillariophyceae also appeared to have a close correlation with silica concentration. Silica is one of the main nutrients for Bacillariophyceae because of its use as the main ingredient for cell wall formation [39].

4. Conclusion
The community structure of phytoplankton at Segara Anak Lake, Mount Rinjani National Park (TNGR) was spatially and temporally different. The environmental factor and nutrient had an influence on the composition of phytoplankton at Segara Anak Lake. There were 19 genera of phytoplankton dominated by Cyanophyceae class.

Suggestion
It is needed for the wider range of research related to the influence of some variables of the abundance of phytoplankton at Segara Anak Lake, such as micronutrient analysis related to the abundance of phytoplankton and the other volcanic materials.

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