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Diversity of plankton in the waters of sanghyang kenit Rajamandala cave, Indonesia

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ABSTRACT

Sanghyang Kenit Cave is a cave that has an aquatic environment and a potential habitat for plankton. Plankton can be a bioindicator of water because of its sensitivity to the environment. The purpose of this study was to determine the diversity, interrelationship factors, and linkages of plankton with the environment in the waters of Sanghyang Kenit Rajamandala Cave, West Bandung. This research was conducted from August 2021 to September 2022. The study employed a purposive sampling method, identifying three sampling zones (The Light, Twilight, and Dark zones) during morning, afternoon, and evening periods. Sampling was done by taking a sample of 10 liters and then filtering using plankton net. The Physico-chemical parameters measured included water temperature, light intensity, pH, DO, salinity, nitrate, and phosphate. Based on the results of data analysis found 4 classes with 12 plankton morphospecies. Diversity index values in the Light zone (1.10), Twilight zone (1.08), and dark zone (1.08). Abundance index value in the light zone is 2.537 cells/L, the twilight zone is 501 cells/L, and the dark zone is 29 cells/L. Diversity and plankton in the waters of Sanghyang Kenit Cave have a very strong correlation with water temperature, light intensity, and pH of water. This can be the basis for the development of further research on the management and monitoring of caves that are used as tourist attractions.

Introduction

Indonesia is an archipelagic country that has karst areas spread over almost all major islands from Sumatra to Papua. However, until now the existence of karst areas in Indonesia itself still provides little information about the potential for life in caves. Biological research that provides information about cave ecosystems in Indonesia itself has not been done much. This makes the lack of knowledge about the study of life in the cave, especially in the study of the existence of plankton which is one of the main sources of energy for the level of life of other organisms.

Cave is a place that is quite foreign to the life of an organism. The extreme characteristics of the cave environment make it difficult for an organism to survive. This is due to the limitations of life-supporting factors in the cave environment such as low light conditions, low air circulation, high humidity, and minimal habitat variation (Kurniawan and Rahmadi, 2019). Such environmental conditions result in reduced ecosystem diversity in the cave, only a few groups of highly adaptive taxa will be able to survive in a completely limited cave environment (Mammola, 2018).

Sanghyang Kenit Cave is a horizontal cave located in Rajamandala Kulon Village, Cipatat District, West Bandung Regency. Inside the Sanghyang Kenit Cave there are waters that have the potential to be a habitat for plankton. Plankton are aquatic organisms whose life character floats in water. Plankton can be used as a water quality bioindicator because it is sensitive to several pollutants. In addition, plankton has an important role in the ecosystem that is able to convert inorganic compounds into organic compounds, and is also able to produce oxygen from photosynthesis which is needed by living things (Usman, 2013).

Sanghyang Kenit Cave has now been developed into a Tourism Cave because it has an attraction for its natural beauty. The cave that is used as a tourist attraction is one option that is considered more

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environmentally friendly. In fact, the use of caves as a tourist attraction also has a negative impact that can damage the cave ecosystem. The presence of humans can change the microclimate in the cave so that it disturbs the biota in it. Human tread on aquatic habitats can disrupt hydrological flow and disrupt microhabitats such as making the water cloudy and also changing the composition of the substrate (Kurniawan and Rahmadi, 2019). In addition, the hills around Sanghyang Kenit Cave have also been mined. These mining activities have a negative impact on the cave ecosystem because they can damage the hydrological flow by cutting off underground rivers. As a result, the porosity of the rock will be lost so that it interferes with the entry of water which is one of the important agents for the entry of organic matter for the life of aquatic biota. The river around Sanghyang Kenit Cave is also used by the community for daily activities, but the quality of the water is not yet known.

Until now, scientific data regarding the diversity of biota in Sanghyang Kenit Cave is still minimal, especially plankton that is not yet available. In addition, considering the magnitude of the threat to the sustainability of the ecosystem and the water quality around the cave, plankton inventory is important. Plankton in waters can provide information on the state of an ecosystem as well as make indicators in evaluating the level of quality and fertility of these waters (Melati *et al,* 2005). According to Suherman (2005), plankton is also the main energy source in the food chain for the life of other aquatic biota, therefore the distribution pattern and structure of the plankton community in a waters can be used as one of the biological indicators in determining changes in the conditions of a waters.

Data regarding biota diversity in Sanghyang Kenit Cave is still minimal, especially regarding plankton data which is not yet available. In addition, considering the magnitude of the threat to the preservation of the cave ecosystem and information about the water quality around the cave makes an inventory of plankton diversity very important. Therefore, research on the diversity of plankton in the waters of Sanghyang Kenit Cave needs to be carried out with the aim of knowing the condition of the cave's aquatic ecosystem by looking at data on diversity, abundance and the relationship between plankton and physical and chemical factors. Another thing, this research can be used as a basis for monitoring ecosystem changes and considerations related to the management of the Sanghyang Kenit Rajamandala Tourism Cave, Bandung, West Java.

Materials and Methods

Location and time of research

This study uses a natural snapshot experiment (NSEs) approach to compare the diversity, abundance, and habitat characteristics of the various species found. The method used is descriptive exploratory, namely the analysis and presentation of data based on objects obtained in the habitat so that it can be concluded and understood (Priyono, 2016).

Determination of Location and Sampling Techniques

Plankton sampling was carried out in the waters of Sanghyang Kenit Cave which is located at 06º 51'50ºS 107º20'55"E. Sanghyang Kenit Cave is located in Rajamandala Kulon Village, Cipatat District, West Bandung Regency, West Java Province (Figure 1). Determination of the sampling location based on zoning, namely the Light zone, Twilight zone and dark zone with the sampling technique using the purposive sampling method. In each zone, 3 sampling points were determined, namely edge 1, middle and edge 2. Sampling of plankton using a bucket with a volume of 10 liters, then the collected water was poured into plankton net so that it was filtered and transferred to a 25 ml sample bottle. It was repeated 3 times at each point so that 27 replications were obtained. After that, 4 drops of 4% formalin were added to the sample, then the bottle was tightly closed and labeled (Oktavia *et al*., 2015).

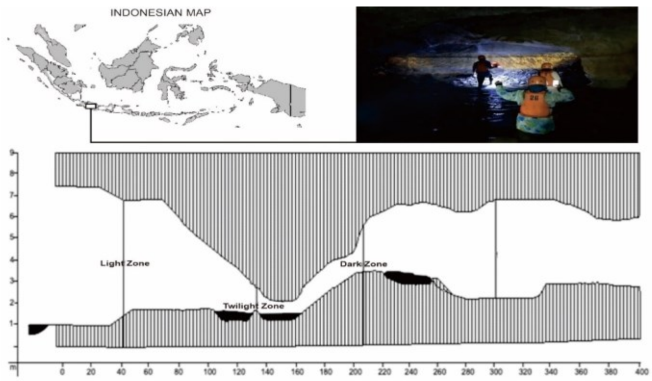

Figure 1. Illustration of Sampling Points in Each Zone of Sanghyang Kenit Cave Sampling View.

Data analysis

The observed variables included composition, diversity, uniformity, dominance, plankton abundance in each zone, physical and chemical parameters including light intensity, water temperature, salinity, dissolved oxygen content in the waters, acidity, nitrate and phosphate. Several analyzes were carried out, including:

1. Species Diversity

This analysis serves to determine the diversity of plankton species in the underground river Sanghyang Tikoro Cave. Plankton diversity was calculated by the Shannon-Wiener (Odum, 1993) formula:

$$H' = -\sum \left(\frac{ni}{N}\right) ln \left(\frac{ni}{N}\right)$$

Information :
H' = Shannon-Wiener diversity index
ni = Number of individuals of the 1st species
N = Total number of individuals of all species

2. The uniformity of plankton

This analysis is used to determine the distribution conditions of plankton in a particular location (Samudra *et al.*, 2013).

$$E = \frac{H'}{H'maks}$$

Information :
E = Uniformity Index
H' = Shannon-Wiener Diversity Index
H'max = Maximum diversity index (ln S, where S = Number of species)

3. Dominance Index

This analysis serves to determine the dominance of certain species. The dominance index can be calculated using the Simpson (1949) formula (Roziaty *et al.*, 2018).

$$C = \sum_{i=1}^{n} \left[\frac{ni}{N}\right] x \left[\frac{ni}{N}\right]$$

Information :
C = Dominance index
ni = Number of individuals of the 1st species
N = Total number of individuals of all species

4. Abundance of Plankton

The abundance of plankton is used to determine the amount of plankton per liter, so that it can describe the state of the environmental carrying capacity of the biota in the habitat (Noventalia *et al.*, 2012). Abundance can be calculated using the formula APHA (1992).

$$N = \frac{Oi}{Op} x \frac{Vr}{Vo} x \frac{1}{Vs} x \frac{n}{p}$$

Information :
N = Number of individuals/m³
Oi = Area of the cover glass (mm²)
Op = Area of one field of view (mm²)
Vr = Volume of filtered water (ml)
Vo = Observed water volume (ml)
Vs = Volume of filtered water
N = Number of plankton in the entire field of view
P = Number of observed field of view

5. Correlation Analysis

Correlation analysis was conducted to determine the close relationship between abiotic factors that have been measured with plankton. The analysis was carried out using IBM SPSS version 26 software.

Results

Diversity and Composition of Plankton in the Waters of Sanghyang Kenit Cave

In this study, the plankton found in the waters of Sanghyang Kenit Rajamandala Cave, West Bandung Regency, consisted of 4 classes and 12 genera. These classes comprised Bacillariophyceae, Chlorophyceae, Cyanophyceae, and Rotifera. In the light zone, 3 classes of phytoplankton were found: Bacillariophyceae with 5 genera, Chlorophyceae with 4 genera, and Cyanophyceae with 2 genera. In the twilight zone, 2 classes of phytoplankton were observed, namely Bacillariophyceae with 2 genera and Chlorophyceae with 1 genus. Additionally, the twilight zone exhibited 1 class of zooplankton, Rotifera, with 1 genus. Meanwhile, in the dark zone, there was 1 class of phytoplankton (Bacillariophyceae) with 1 genus and 1 class of zooplankton (Rotifera). Figure 2 and Table 1 depict the diversity and composition of plankton in the waters of Sanghyang Kenit Cave.

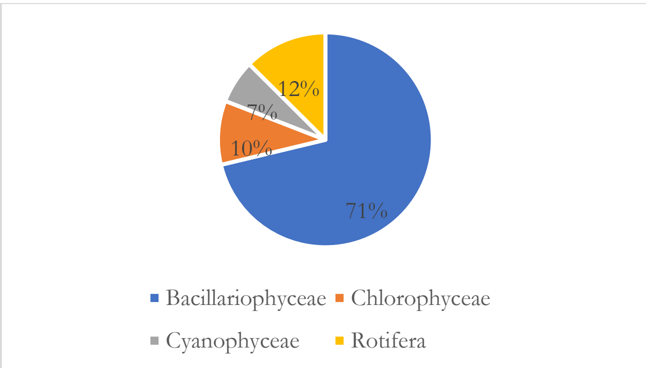

Figure 2. Plankton Class Composition.

Table 1. Diversity of Plankton in the Waters of Sanghyang Kenit Cave.

Kelas	Morfospesies
Bacillariophyceae	*Acnanthes* sp, *Coscinodiscus* sp, *Cymbella* sp, *Navicula* sp, *Synedra* sp.
Chlorophyceae	*Osmarium* sp, *Euastrum* sp, *Spyrogira* sp, *Tetrastrum* sp.
Cyanophyceae	*Merismopedia* sp, *Oscilatoria* sp.
Rotifera	*Notholca* sp.

The total abundance of plankton based on observations in three zones with three sampling times in the waters of Sanghyang Kenit Cave showed varying results, presented in Figure 3. Based on the graph in Figure 3, the highest abundance of plankton was obtained in the Light zone with an average of 2,537.3 Individu/ L. The abundance of plankton was seen to decrease drastically in the twilight zone, with an average of 501.3 Individu/ L. Then in the dark zone, the abundance of plankton decreased again and made the dark zone the zone that had the least abundance of plankton with an average of 29.3 Individu/ L.

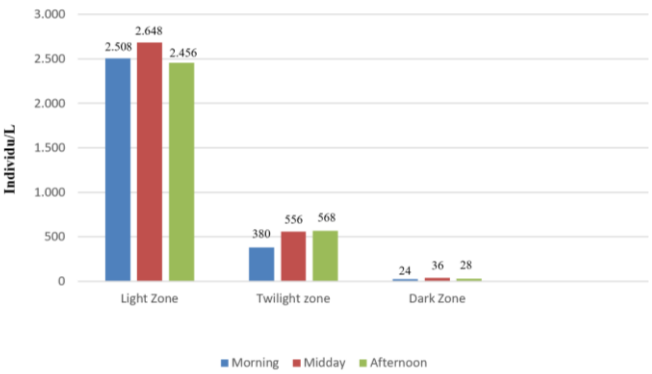

Figure 3. Plankton Abundance.

Table 2. Differences in Morphospecies Composition Between Zones.

Morphospecies	Light Zone	Twilight Zone	Dark Zone
Acnanthes sp.	√	-	-
Coscinodiscus sp.	√	-	-
Cymbella sp.	√	-	-
Navicula sp.	√	√	-
Synedra sp.	√	√	√
Cosmarium sp.	√	-	-
Euastrum sp.	√	-	-
Spyrogyra sp.	√	√	-
Tetrastrum sp.	√	-	-
Merismopedia sp.	√	-	-
Oscilatoria sp.	√	-	-
Notholca sp	-	√	√

The composition of plankton morphospecies based on observations in three zones across three sampling periods in the waters of Sanghyang Kenit Cave shows varying results, presented in Table 2. The analysis of diversity index was employed to ascertain the plankton diversity in the research locations conducted in the waters of Sanghyang Kenit Cave. The results of diversity index in each zone can be seen in Table 3. The results of calculating the evenness index (E) are utilized to determine the level of species evenness of plankton in a water body.

Table 3. Plankton Diversity Index.

Zone	Index Diversity (H') Plankton
Light	1,10
Twilightly	1,08
Dark	1,08

The evenness index value can indicate species' tolerance levels to the environmental quality of a water body. The outcomes of the evenness index value (E) for plankton in each zone of Sanghyang Kenit Cave waters are presented in Table 4.

Table 4. Plankton Uniformity Index.

Zone	Uniformity Index (E) Plankton
Light	0,44
Twilight	0,43
Dark	0,43

The results of calculating the dominance index (C) are utilized to determine the level of plankton species dominance in specific water bodies. Dominance itself is defined as individuals holding higher resources or social status compared to others. The outcomes of the dominance index calculations (C) in the waters of Sanghyang Kenit Cave can be seen in Table 5.

Table 5. Plankton Dominance Index

Zone	Plankton Dominance Index (C)
Light	0,333
Twilight	0,343
Dark	0,342

The results of measuring water quality parameters in the waters of Sanghyang Kenit Cave are presented in Table 6, encompassing physical parameters (light intensity and temperature) as well as chemical parameters (salinity, pH, dissolved oxygen, total phosphate, and total nitrate).

Table 6. Physical and Chemical Parameters

Zone	Parameter						
	Temperature (°C)	Light intensity (lx)	pH	DO (mg/L)	Salinity (0/0o)	Total Nitrate (mg/L)	Total Phosphate (mg/L)
Light	26,5	10.051,4	7,69	1,169	0	0,029	0,104
Twilight	24,7	0,14	7,73	0,121	0	0,039	0,265
Dark	24	0	8,83	0,132	0	0,037	0,221

The results of the correlation analysis between environmental parameters and the diversity and abundance of plankton show both strong and weak associations. Significant relationships are indicated by values (>0.05), signifying a strong correlation. The correlation analysis outcomes are presented in Table 7.

Table 7. Correlation of Diversity and Abundance Index to Environmental Factors.

Environmental Parameters	Correlation Coefficient (r)	
	Diversity	Abundance
Temperature	0,866	1.000**
Light intensity	1.000**	0,866
pH	-0,866	1.000**
DO	0,866	0,5
Salinity	-	-
Total Nitrates	0,866	-0,5
Total Phosphate	-0,866	-0,5

Discussion

Based on observations in three zones and three different times in the waters of Sanghyang Kenit Cave, the highest plankton composition was found in the Bacillariophyceae class with a percentage of 71%. This is because this class of phytoplankton has good adaptability and can also grow in waters with low light conditions, so that it is able to reproduce and regenerate in greater numbers than other phytoplankton classes (Haryoko *et al.*, 2018).

According to Novia *et al.* (2016), the Bacillariophyceae class can live in various types of different habitats and survive changes in temperature in the waters, their presence also has a wide distribution in the waters. The high abundance of the Bacillariophyceae class is because this organism is dominantly found in almost every type of aquatic habitat (Wiyarsih *et al.*, 2019). The data is presented Figure 1.

Rotifers belong to the zooplankton class that dominates the waters of Sanghyang Kenit Cave. The percentage reaches 12%, this is in accordance with Toruan (2015) statement that Rotifers are a class of zooplankton that have the highest species composition in the waters and can adapt well in all water conditions. In addition, the amount of organic matter contained in the waters of Sanghyang Kenit Cave such as nitrate and phosphate provide support for the growth of the Rotifera class.

Chlorophyceae is a class of phytoplankton that dominates after the class Bacillariophyceae which is as much as 10%. Chlorophyceae are usually found in relatively calm waters (Yati, 2015). The class Chlorophyceae is mostly found in the Light zone and is also found in the Twilightly lit zone with fewer numbers. This is presumably because in the Light zone the optimal temperature for phytoplankton growth is between 25^0-29^0C, while in the Twilight zone the water temperature decreases between 24^0-25^0C. Another factor that also affects the growth of Chlorophyceae is light intensity, the Light zone has sufficient light intensity, which ranges from 1,055-38,300 while the Twilight zone has very less light intensity for phytoplankton life, which is 0.14 lx.

Cyanophyceae is a class of phytoplankton with the least composition in the waters of Sanghyang Kenit Cave, which is 7%. The Cyanophyceae class is also only found in the Light zone because the temperature measured in the Light zone ranges from 250-290C, this value corresponds to the optimum temperature for phytoplankton life. According to Widiana (2012), the small amount of abundance in the Cyanophyceae class is not a factor in polluted waters because the Cyanophyceae class can also grow in waters that are less than optimal and get less sunlight. The composition of plankton is presented in Table 1 and Figure 2.

The morphospecies composition of plankton based on observations in three zones with three sampling time periods in the waters of Sanghyang Kenit Cave showed different results. In the Light zone, 11 plankton genera were found including *Acnanthes* sp., *Coscinodiscus* sp., *Cymbella* sp., *Navicula* sp., *Synedra* sp., *Cosmarium* sp., *Euastrum* sp., *Spyrogira* sp., *Tetrastrum* sp., *Merismopedia* sp., and *Oscilatoria* sp. In the Twilightly lit zone, four genera of plankton were found, namely *Navicula* sp., *Synedra* sp., *Spyrogira* sp., and *Notholca* sp. In the dark zone, only two plankton genera were found, namely *Synedra* sp. and *Notholca* sp. (Table 2).

There are several genera that are only found in the Light zone including *Acnanthes* sp., *Coscinodiscus* sp., *Cymbella* sp., *Cosmarium* sp., *Euastrum* sp., *Tetrastrum* sp., and *Merismopedia* sp. The genus was not found in the Twilight zone and the dark zone, presumably because there were differences in environmental factors between the Light zone and the Twilight zone and the dark zone such as the lack of light intensity in the Twilight zone and the dark zone so that the plankton genus could not survive. According to Nurfadillah *et al.* (2004), it has long been known that sunlight has an important role for the life of organisms, especially its intensity which is one of the determinants of the productivity of a waters. Light intensity is a very important factor limiting the vertical distribution of phytoplankton in the waters, therefore phytoplankton are only able to be in the upper part of the waters.

Synedra sp. found in each zone, namely the Light zone, the Twilight zone and the dark zone. According to Lantang and Pakidi (2015) Synedra sp. has a high tolerance for environmental changes such as light intensity, temperature, pH and salinity so that it can survive in different environmental conditions. Differences in morphospecies composition between zones are presented in Table 2.

Diversity index analysis was used to determine the diversity of plankton from the research location in the waters of Sanghyang Kenit Cave. The results of the diversity index in table 3 show that the plankton diversity index in the waters of Sanghyang Kenit Cave is included in the category of moderate diversity. Where in the light zone the diversity index (1.10), the twilight zone (1.08), and the dark zone (1.08). Based on Shannon-Wiener in (Odum, 1993), the criteria for the level of diversity include: H' < 1 means low diversity and plankton in an unstable state, 1 < H' < 3 means moderate diversity and stability of plankton in moderate condition, H' > 3 means high diversity and stability of plankton in very good condition. The data is presented Table 3.

The distribution of individuals in each species affects the value of diversity, an ecosystem that has many types but the distribution is uneven, the index value diversity will be low (Meiwinda *et al.,* 2015). In the Twilight and dark zones, lower values were obtained compared to the Light zones, this was due to the fewer types of plankton and their number as well as environmental factors such as less light intensity (Bialangi, 2005). According to Odum (1993) the diversity index shows the number of species that can adapt to the environment in which these organisms live. The higher the diversity index value, the more species that can live in the environment. The lower the abundance of plankton in a waters, the lower the species diversity and the higher the abundance of plankton in a waters, the higher the species diversity.

The results of the calculation of the uniformity index (E) are used to determine the level of uniformity of plankton species in a waters. The value of the uniformity index can show species with the ability to tolerate environmental quality in a waters. Based on table 4, the uniformity index generated in the Light zone is (0.44), the Twilight zone (0.43), and the dark zone (0.43). The uniformity index value is low because it is close to zero. That matter indicates that the composition of plankton in the waters of Sanghyang Kenit Cave is not uniform because there is a dominant distribution of certain species. The uniformity index ranges from 01, if the value of E is close to 0 then the distribution of individuals between the sexes is not evenly distributed and if the value of E is close to 1 then the distribution of individuals between species is evenly distributed (Odum, 1993). The data is presented Table 4.

The low or near zero uniformity index value is influenced by the number of organisms, species uniformity, the dominance of certain individuals, destruction of natural habitats, climate change, chemical pollution and organic matter (Widodo, 1997). The uniformity index value in each zone is low, presumably because there are tourist activities around Sanghyang Kenit Cave, it can damage the natural habitat of the organisms that live in it. In addition, the lack of nutrient availability also affects the life of plankton, thereby creating competition for food.

The results of the calculation of the dominance index (C) are used to determine the level of dominance plankton species in certain waters, are presented in Table 5. Self-dominance is defined as individuals who have higher resources or social status than other individuals. The dominance index obtained based on the analysis for the waters of Sanghyang Kenit Cave in the Light zone (0.333), the Twilight zone (0.343), and the dark zone (0.342). Based on this value, it can be seen that the dominance index in the waters of Sanghyang Kenitter Cave is low. This shows that there is no type of plankton that dominates these waters. The value of the plankton dominance index ranges from 0 to 1, if the dominance index is close to 0 it means that in the observed biota community structure there are no species that prominently dominate other species (Basmi, 2000). The data is presented Table 5. The value of the dominance index generated in each observation zone is caused by physical and chemical factors in the waters so that it affects the survival of plankton to survive. Factors that influence plankton to survive in waters include: currents, wind, nutrients, temperature, light, Lightness, turbidity, depth and pH (Meiwinda *et al.,* 2015).

The highest abundance of plankton is in the Light zone. This is influenced by the intensity of light that is sufficient for plankton life. The average light intensity in the Light zone is 10,051.4 lx. Light in the waters has a direct or indirect influence on an environment. The intensity of light can indirectly affect the abundance of zooplankton food, namely phytoplankton that need light to photosynthesize (Bramasta *et al.,* 2020). In the Twilight zone and the dark zone the light intensity is very minimal at 0.14 lx, this affects the decreasing abundance of plankton. According to Abida 2010, the difference in the abundance value of phytoplankton can be caused by several factors including: the availability of nutrients, the presence of light in the water column and the rate of grazing by other organisms. Besides, Goldman and Horne in Pratiwi *et al.* (2015) revealed that the factors supporting the growth of plankton are very important complex and interacting between water physico-chemical factors such as the availability of nitrogen and phosphorus nutrients, light intensity, temperature stratification as well as dissolved oxygen, while the biological aspects are predation activities by animals, natural mortality, and decomposition.

Based on the table above (Table 6), it is known that the water temperature in the waters of Sanghyang Kenit Cave ranges between 24°C to 26.6°C. According to Barus (2004), water temperature can relate to the condition of the water body and the organisms within it. When the water temperature is too high, it can decrease the water's ability to retain oxygen, thereby disturbing the organisms living within it. The water temperature values recorded in the waters of Sanghyang Kenit Cave may support plankton growth, as Nybakken (2004) suggests that plankton generally thrives in temperatures ranging from 20°C to 30°C. There are temperature variations in each zone, caused by differences in location, water flow sources, seasonal influences, and measurement timings. Temperature is also influenced by several factors such as rainfall, humidity, evaporation, wind speed, and light intensity (Suhana, 2018). The water temperature in the Light zone is higher compared to the Twilight and Dark zones because the Dark zone receives no sunlight at all, resulting in a light intensity value of 0 lx. Meanwhile, the Light and Twilight zones still receive some sunlight. Water temperature itself is significantly affected by light intensity. Data is presented in Table 6.

Water temperature also affects the abundance of plankton. The average water temperature in the Light zone is 26.5°C, so plankton can grow well in this zone and the abundance is the highest compared to the other two zones. According to (Nontji, 2008) the optimum temperature for plankton growth ranges from 25°C-30°C. Meanwhile, in the Twilight zone the average water temperature is 24.7°C and in the dark zone 24°C. With this water temperature, the growth of plankton is not optimal so that it affects its abundance decreases. As important as temperature and light intensity, dissolved oxygen or DO also affects the survival of plankton. The higher the dissolved oxygen content in the water, the more optimal the ability of phytoplankton to photosynthesize because phytoplankton contribute oxygen. In the Light zone which has the highest abundance value, the dissolved oxygen in the water is on average 1.169 mg/L. Meanwhile, in the Twilightly lit zone, the dissolved oxygen in the water is on average 0.121 mg/L and in the dark zone is 0.132 mg/L.

Differences in abundance are also influenced by freshwater and marine environmental conditions which cause significant differences (Campbell and Reece, 2010). Salinity in the Light zone, Twilight zone and dark zone is worth 0 0/00, even though the higher the salinity, the higher the energy of plankton for growth and the lower the salinity level, the plankton will find it difficult to survive.

The light intensity value obtained in the Light zone of Sanghyang Kenit Cave waters is 10,051.4 lx, while in the Twilight zone it is 0.14 lx and in the dark zone is 0 l x. The difference in values is due to the different measurement locations in each zone. In the Light zone, the area is open and very exposed to sunlight, on the contrary in the dark zone the area is closed and no longer exposed to sunlight so that sunlight cannot enter at all and becomes completely dark, in the Twilight zone the light entering is very minimal and almost dark. . The difference in the value of light intensity affects the life of plankton because according to Meiwinda *et al.* (2015) one of the factors that influence plankton to survive in a waterwaterht intensity.

The results of the measurement of the degree of acidity or pH in the waters of Sanghyang Kenit Cave ranged from 7.69-8.83. The highest pH value is in the dark zone while the lowest pH value is in the Light zone. The pH value in the dark zone is more alkaline than in the Light zone and Twilightly lit zone because in the dark zone there are very few human activities, while in the Light zone and Twilightly lit zones are often traversed or become the location of activities carried out by humans. According to Herlambang (2006) one of the causes of a decrease in water pH is human activity. Waters with a pH of 7-9 are productive waters cane to break down organic matter into minerals to be utilized by plankton (Nirmalasari *et al.,* 2014). Thus, the waters of Sanghyang KeniKnite are productive in terms of their pH value. According to Harmoko and Sepriyaningsih (2018) the degree of acidity is a parameter that shows the activity of hydrogen ions in aater, acid, and base can be used as a pH balance value.

The content of dissolved oxygen or DO in the waters of Sanghyang Kenit Cave in each zone ranges from 0.121 to 1.169 mg/L. The highest concentration was in the Light zone with a value of 1.169 ml/L and the lowest concentration was in the Twilight zone, namely 0.121 mg/L. With this value, it can be said that the dissolved oxygen content in the waters of Sanghyang Kenit Cave is low and can interfere with the growth of organisms in the water, including plankton, because according to Effendi (2003) the optimum DO for plankton life ranges from 5.45-7.00 mg/day. L. Low DO levels can be caused by the release of oxygen into the air, respiration of biota, reduction of gas friction in water, the presence of iron and decomposition of organic matter. Dissolved oxygen content in water can come from air diffusion, agitation by wind and phytoplankton photosynthesis.

The salinity value in each zone in the waters of Sanghyang Kenit Cave is 0 0/00. The value of 0 0/00 generated in the measurement is thought to be because there is a freshwater river around the cave that irrigates the deep waters of Sanghyang Kenit Cave. According to Nontji (2008), salinity can affect the distribution of plankton. The higher the salinity, the higher the energy of plankton for growth and the lower the salinity level, the more difficult it is for plankton to survive.

The value of nitrate content in the Light zone is 0.029 mg/L, the Twilight zone is 0.039 mg/L and the dark zone is 0.037 mg/L. According to Basmi (2020), the optimal level of nitrate for phytoplankton growth is around 3.9 mg/L 15.5mg/L. Thus the total nitrate in the three zones in the waters of Sanghyang Kenit Cave is less able to nourish phytoplankton and affect zooplankton life. The role of nitrate as a nutrient is very important for the growth of phytoplankton which is a food source for zooplankton. The presence of nitrate in an aquatic ecosystem is influenced by fertilization activities and industrial waste. Meanwhile, sources of nitrate can also come from air pollution produced by industry, motorized vehicles, and the impact of acid rain. The results of data analysis show low nitrate levels in the waters of Sanghyang Kenit Cave, indicating that the waters have not been polluted. Apart from that, the location of the cave which is quite far from industrial areas can also be a factor that contributes to the cleanliness of the waters.

Optimal phosphate levels for phytoplankton growth range from 0.27-5.51 mg/L (Wardhana *et al.,* 2013). The value of phosphate levels in the Light zone is 0.104 mg/L, the Twilight zone is 0.265 mg/L and the dark zone is 0.221 mg/L. it can be said that the phosphate levels in the waters of Sanghyang Kenit Cave are less than optimal for phytoplankton growth and will also affect the growth of zooplankton. According to Suwarno and Idris (2007), the presence of phosphate in waters can be influenced by guano which is rich in phosphate. The higher phosphate content in the Twilight zone and dark zone is thought to be due to the presence of bat droppings that fall into the waters of the zone.

The light intensity has a very strong correlation with the diversity index as well as the plankton abundance index, the correlation values are 1000 and 0.866. The nature of the correlation between light intensity with diversity index and plankton abundance index is positive (+) which means that all three are in the same direction. The higher the light intensity, the higher the diversity and abundance index. Conversely, the lower the light intensity, the lower the diversity index and abundance of plankton. Optimal light intensity is very useful for phytoplankton to photosynthesize. pH has a very strong correlation with the diversity index as well as the plankton abundance index, the correlation values are -0.866 and 1000.

The nature of the correlation between light intensity with diversity index and plankton abundance index is negative (-) which means the lower the pH, the higher the diversity and abundance index of plankton. On the other hand, the higher the pH, the lower the diversity index and abundance of plankton. Changes in pH greatly affect the life of plankton, the influence of pH is very large on the metabolic processes and respiration of plankton (Wijayanti, 2007). According to Yuliana *et al.* (2012), a very low pH can threaten the life of aquatic organisms because a very low pH can increase the presence of the toxin compound DO (Dissolved oxygen) which has a very strong correlation with the plankton diversity index, the correlation value is 0.866. The nature of the correlation between DO and the plankton diversity index is positive (+) which means both are parallel.

The higher the DO concentration, the higher the diversity index. On the other hand, the lower the DO concentration, the lower the plankton diversity index. In addition, DO has a moderate correlation with the plankton abundance index, the correlation value is 0.5. The nature of the correlation between DO and the plankton abundance index is positive (+) which means they are in the same direction. The higher the DO concentration, the higher the plankton abundance index. On the other hand, the lower the DO concentration, the lower the plankton abundance index. The high and low concentrations of DO can also affect the turbidity of the water and the activity of aquatic biota. DO concentration can also indicate the status of water quality, therefore it can affect the diversity and abundance of plankton (Patty, 2015).

The results of the correlation test analysis between environmental parameters and the diversity and abundance of plankton showed a strong or weak relationship. A significant relationship is worth (> 0.05) which means there is a strong closeness. Based on the analysis of the Spearman correlation test, temperature has a very strong correlation with the diversity index and plankton abundance index. The nature of the correlation between temperature with diversity index and plankton abundance index is positive (+) which means that all three are in the same direction. The higher the temperature value, the higher the diversity and abundance index value. Vice versa (Chusnan, 2018). One of the important factors in the distribution of organisms is the ambient temperature. The data is presented Table 7.

The correlation coefficient between the salinity value on the diversity index and the abundance index was not detected. This is because the salinity value resulting from measurements in all zones is 0. According to Nontji (2008), salinity can affect plankton distribution. The higher the salinity, the higher the energy of plankton for growth and the lower the salinity value, the more difficult it is for plankton to survive. From this opinion, it can be understood that salinity has a close relationship with the diversity index and plankton abundance index.

Total nitrate and phosphate have a very strong correlation with the plankton diversity index, the correlation value is -0.866. The nature of the correlation between total nitrate and phosphate with the plankton diversity index is negative (-) which means that the three are in opposite directions. The higher the total nitrate and phosphate, the lower the diversity index. On the other hand, the lower the total nitrate and phosphate, the higher the plankton diversity index. In addition, total nitrate and phosphate have a moderate correlation with the plankton abundance index, the correlation value is -0.5. The nature of the correlation between total nitrate and phosphate with plankton abundance index is negative (-) which means the three are in opposite directions.

The higher the total nitrate and phosphate, the lower the plankton abundance index. On the other hand, the lower the total nitrate and phosphate, the higher the plankton abundance index. This is in accordance with the opinion (Ali, 2013) which states that there is a correlation between plankton diversity and turbidity, pH, nitrate and phosphate. The diversity and abundance of plankton is closely related to the levels of nitrate and phosphate in a waters, because nitrate and phosphate are food ingredients for phytoplankton which are food for zooplankton. Therefore, nitrate and phosphate levels are very influential on the diversity and abundance of plankton (Fatmayanti *et al*., 2019).

Based on the results of the Spearman correlation analysis, the relationship between environmental factors and the diversity and abundance of plankton in the waters of Sanghyang Kenit Cave has a very strong correlation with temperature, light intensity and pH. DO, total nitrate and total phosphate have a very strong correlation with the plankton diversity index. Meanwhile DO, total nitrate and total phosphate have a moderate correlation with the plankton abundance index. Thus, several environmental parameters are closely related to the high and low index of diversity and abundance of plankton in the waters of Sanghyang Kenit Cave.

Conclusion

Plankton found in the waters of Sanghyang Kenit Cave, Rajamandala, West Bandung Regency are in 4 classes, namely Bacillariophyceae, Chlorophyceae, Cyanophyceae and Rotifera. The plankton diversity index value in the light zone is 1.10, the twilight zone is 1.08, the dark zone is 1.08 and is included in the medium diversity category. The plankton uniformity index value in the Light zone is 0.44, the Twilight zone is 0.43, the dark zone is 0.43 and includes low uniformity. The plankton dominance index value in the Light zone is 0.333, the twilight zone is 0.443, the dark zone is 0.342 and includes low dominance. The total abundance value of plankton in the waters of Sanghyang Kenit Cave in the Light zone is an average of 2,537 cells/L, the Senja zone is 501 cells/L and the dark zone is 29 cells/L. Water temperature, light intensity and water pH have a very strong correlation and also greatly influence the diversity and abundance of plankton. High water temperature and light intensity values can increase plankton diversity and abundance. On the other hand, low water pH values can increase the diversity and abundance of plankton

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