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Phytoplankton Community Structure in Bun-Bun River Waters, Kubu Raya Regency, West Kalimantan

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Abstract: *The Bun-bun River was located in a mangrove forest area in Kubu Raya Regency and empties into the sea. As the main producers at the trophic level of waters, phytoplankton has an important role in assessing river quality. This study aims to find out phytoplankton community structure including abundance, diversity, uniformity, and dominance indexs in relation to Bun-bun River quality. The observations were made in the dry and rainy seasons at three stations starting from the initial end of the mangrove forest (Station 1), the middle (Station 2), and the final end which also empties into the sea (Station 3). Sampling was carried out at three points (left edge, center, right edge). Measurements of physico-chemical factors include brightness, current velocity, temperature, pH, DO, dissolved CO_2, salinity, nitrate and phosphate. Phytoplankton sampling used a 30 μm plankton net mesh size and identification down to the species level. The calculated index values include abundance, diversity, uniformity, and dominance. The Bun-bun River was characterized by brackish waters with calm surface currents (<0.1 $m.s^{-1}$) and a salinity between 5.4-9.48 ppt. Dissolved CO_2 levels are relatively high, namely 22-30.8 $mg.L^{-1}$ in the dry season and 35.2 $mg.L^{-1}$ in the rainy season. During the dry season, the pH of the water becomes slightly acidic (6.51-6.76) and relatively neutral during the rainy season (7.08-7.52). Nitrate and phosphate levels were low in both seasons and all three stations. The brightness of the water was higher in the dry season than in the rainy season (20-44 cm). A total of 52 types of phytoplankton were found belonging to four classes, namely Class Bacillariophyceae (25 species), Dinophyceae (14), Chlorophyceae (12), and Chrysophyceae (1). Phytoplankton abundance index was low to moderate. The diversity index was moderate at almost all stations except for the low at Station 3 in the rainy season. The uniformity index at Station 3 was low in the dry season but high in the rainy season, and moderate in other locations. The dominance index was high at Station 3 during the dry season and moderate at other locations. Physico-chemical factors such as salinity, dissolved CO_2, nitrate and phosphate levels are most likely to influence abundance, while diversity was influenced by dominance.*

Keywords: *Brackish Waters, Bun-bun River, Community Structure, Phytoplankton, West Kalimantan*

1. INTRODUCTION

Phytoplankton have an important role as producers at the food chain level (Dwirastina & Wibowo, 2015). The lives of other aquatic organisms are also influenced by the presence of phytoplankton in the waters (Syafriani & Apriadi, 2017).

Sulistiowati *et al.*, (2016) stated that water productivity was determined by phytoplankton at the trophic level which functions as a producer. The primary producer is important for sustainability in life process. The sustainability is maintained to energy transfer in the food web. This condition was related to the flow of energy

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in trophic levels through the food chain of a water body.

The Bun-bun River is one of the waters that flows through the mangrove forest area, Batu Ampar District at in Kubu Raya Regency, West Kalimantan. For phytoplankton, mangrove forests contribute very important nutrients such as dry leaf litter and twigs which then decompose. The results of the decay of these nutrients are utilized by phytoplankton for nutrient (Fila *et al.*, 2018). The presence of phytoplankton in a body of water also depends on available nutrients and phytoplankton resistance (Rahman, 2016). The relationship between phytoplankton and well-maintained mangrove forest ecosystems indirectly determines the survival of other aquatic biota in these waters.

Phytoplankton, as a biological parameter, can be used as an indicator to determine the fertility and quality of waters. For example, if the abundance of phytoplankton is high, the waters tend to have a high level of productivity (Fila *et al.*, 2018). Some phytoplankton that are used as bioindicators of waters include the Bacillariophyceae and Chlorophyceae classes because they can live in lightly polluted waters (Aryawati *et al.*, 2021). At the estuary, the Bun-bun River meets the sea in the Maya Strait. In these conditions, tides occur and freshwater and seawater mix. These conditions can influence the structure of the phytoplankton community in the Bun-bun River. Changes in water conditions affect the organisms that live in the river (Darmawan *et al.*, 2018). Environmental parameters such as temperature, pH, brightness, salinity, current speed, dissolved oxygen (DO) and nitrate and phosphate can affect changes in phytoplankton community structure (Sari et al., 2014; Haroon & Hussian, 2017).

Information on phytoplankton community structure in the Bun-bun River, including indications of water quality, fertility and the potential for certain bioindicators was limited. The role of the Bun-bun River for the surrounding mangrove forest ecosystem can also be determined through a well-maintained phytoplankton community structure. This study provides the first information on phytoplankton community structure in Bun-bun River which includes indices of abundance, diversity, uniformity and dominance. Observations were made in the rainy and dry seasons to see the effect of physical and chemical factors on these index values.

2. RESEARCH METHODS

Time and Location of Research

The research was conducted from July to October 2022. Samples were taken twice, namely the dry season in August and the rainy season in October 2022. The research location was in the Bun-bun River which consisted of three stations (Figure 1). The coordinates of each station can be seen in Table 1.

Table 1. The Coordinates of each riset stations in Bun-bun River

Stations	Coordinates
Station 1	0°57′54.75″ S 109°38′17.99″E
Station 2	00°57′48.81″ S 109°37′55.40″ E
Station 3	00°58′21.01″ S 109°37′47.68″ E

Sampling was conducted at three points for each station covering the left, center and right bank of the river. Bun-bun River has a length of 6.375 km with a river width varying from 32.25 to 129.13 m.

Phytoplankton identification was carried out at the Biology Education Laboratory, FKIP, Tanjungpura University. Measurement of physico-chemical factors was carried out both in situ and ex situ. In situ measurements were made for temperature, pH, salinity, brightness, current speed, dissolved oxygen (DO), and dissolved CO_2. Ex situ measurements were conducted for nitrate and phosphate at the Sucofindo Laboratory in Pontianak.

Tools and Materials

Equipment used included a 30 µm mesh size plankton net, 50 mL phytoplankton sample bottle, 100 mL water sample bottle, 5 Liter bucket, secchi disk, ping pong ball, stopwatch, multitester (TDS/EC), DO meter (Dixson), label paper, spray bottle, camera, Olympus CX21 microscope, Sedgwick rafter, dropper pipette, Optilab Advance camera, GPS with AlpineQuest application, and identification book. The materials used are 4% formalin, distilled water, phenolphthalein (PP) indicator, and Na_2CO_3.

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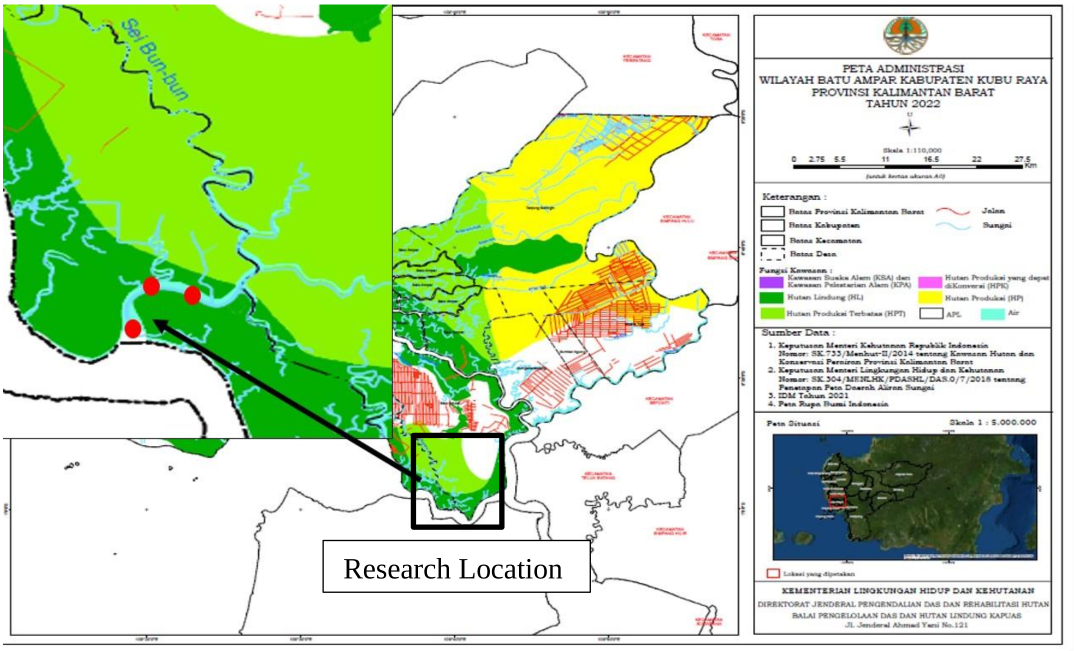

Figure 1. Research location in Bun-bun River, Batu Ampar District, Kubu Raya Regency (Observation stations are marked red) (Source: BPDASHL, 2022)

Data Collection Techniques

The method was survey with purposive sampling technique to measure phytoplankton abundance and diversity.Samples were taken at three stations that were determined from their position to the mangrove forest along the Bun-bun river. Station 1 was at the beginning of the river adjacent to the mangrove forest. Station 2 was in the middle of to other stasions and close to the creek. Station 3 was at downstream which also leads to the estuary in the Maya Strait (Figure 1). The difference location each station would determine variation phtyoplankton affect by difference condition. So that, sampling represented phytoplankton in Bun-bun river. At each station, three sampling points for phytoplankton and water samples were taken, namely 1 m from the left , the center, and 1 m from the right bank.

At each point, phytoplankton and water samples were taken to measure nitrate and phosphate levels. Phytoplankton sampling was done by taking 100 L of water with a 5 L bucket and then filtered with a 30 µm mesh size plankton net. Filtered phytoplankton samples were put into 50 mL sample bottles and given 4% formalin as much as 1 mL. The sample bottles were labeled for subsequent identification in the laboratory.

Phytoplankton identification was done up to the species level. A total of 1 mL of sample was put into a Sedgwick rafter and then covered with a cover glass. The sample was placed on the preparation table and then observed using an Olympus CX21 microscope with a magnification of 10x10. Identification was done by looking at the morphological characteristics. Observations were documented with an Optilab Advance camera. Observations were made three times from the same sample. Phytoplankton species were identified and counted from each point and station. The reference used to identify was referring to Prescott (1964), Tomas (1997), Biggs & Kilroy (2000), Botes (2003), Vuuren, *et al.*, (2006), and research results related to the same type of species.

Physical factors measured included temperature, brightness and current speed, while chemical factors included salinity, pH, DO, dissolved CO_2, nitrate and phosphate levels. Current speed was measured with the help of ping pong balls and brightness with the secchi disk method. Temperature, pH, and salinity were measured using a multitester, while DO was measured using a DO meter. Dissolved CO_2 was measured using the titration method with Na_2CO_3 and phenolphthalein (PP) indicator. The nitrate test was conducted using the SNI 6989.71:2019

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method, while the phosphate test was conducted using the SNI 06-6989.31-2005 method.

Data Analysis

Data were analyzed by calculating abundance, diversity, uniformity and dominance indices. Phytoplankton abundance was calculated referring to APHA (2005) with the following formula:

$$\mathbf{N} = \frac{\mathbf{C \times 1000}}{\mathbf{L \times D \times S}} \ \mathbf{...(1)}$$

Description:

N	=	total phytoplankton abundance
C	=	number of individuals found
L	=	length of the S-R groove
D	=	height of the S-R groove
W	=	groove width
S	=	number of grooves counted

Phytoplankton abundance can be used as an indicator of water fertility. According to Raymont (1980), based on the abundance of phytoplankton, the category of water fertility was divided into three, namely phytoplankton abundance between 0-2000 ind.L^{-1} with oligotrophic category (very low fertility), phytoplankton abundance between 2000-15000 ind.L^{-1} with mesotrophic category (moderate fertility), and phytoplankton abundance of more than 15,000 ind.L^{-1} with eutrophic category (fertile waters).

The diversity index was calculated according to the following Shannon-Wiener equation:

$$H' = -\sum \boldsymbol{pi} \ln \boldsymbol{pi} \ ...(2)$$

Description:

H’	=	*Shannon-Wiener* diversity index
Pi	=	n_i/N
n_i	=	number of individuals of the species *i*
N	=	total number of phytoplankton

The range of diversity index values was classified into low diversity (H' < 1), medium diversity (1 ≤ H' ≤ 3), and high diversity (H' > 3). (Odum, 1993). (Odum, 1993).

The uniformity index was calculated using the following formula:

$$\mathbf{E} = \frac{\mathbf{H'}}{\mathbf{Hmax}} \ .....(3)$$

Description:

E	=	uniformity index
H’	=	Shannon-Wiener diversity index
Hmax	=	lnS (S = number of species)

The grouping of biota community conditions based on the uniformity index value is low community uniformity (E < 0.4), medium community uniformity (0.4 ≤ E ≤ 0.6) and high community uniformity (E > 0.6) (Odum, 1993).

The dominance index is calculated using the following formula:

$$\boldsymbol{C} = \sum_{i=1}^{n} \left(\frac{\boldsymbol{ni}}{\boldsymbol{N}}\right)^2 ....(4)$$

Description :

C	=	Simpson dominance index
n_i	=	number of individuals of species -*i*
N	=	total number of individuals

The grouping of biota community conditions based on the dominance index value (Odum, 1998). The community dominance is categories in to low (C < 0.4), medium (0.4 ≤ C ≤ 0.6), and high (C > 0.6) (Odum, 1998).

3. RESULTS AND DISCUSSION

Results

The measurement results of physical and chemical factors in Bun-bun River can be observed in Table 2.

Table 2. Measurement Results of Physical and Chemical Factors of Bun-bun River at Three Stations in the Dry (August 2022) and Rainy (October 2022) Seasons

Parameter	Station 1		Station 2		Station 3	
	Dry Seasons	Rainy Seasons	Dry Seasons	Rainy Seasons	Dry Seasons	Rainy Seasons
Temperature (°C)	30,5	28,9	32,8	28,4	30,9	28,6
Brightness (cm)	42	37,5	44	20	44	34,5
Current speed (m.s^{-1})	0,09	0,02	0,06	0,03	0,01	0,10
pH	6,76	7,18	6,51	7,52	6,76	7,08
Salinity (ppt)	5,44	7,22	6,40	9,43	7,90	9,48
Dissolved DO (mg.L^{-1})	6,3	5,8	4,9	5,5	3,7	5,2

Quagga
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Parameter	Station 1		Station 2		Station 3	
	Dry Seasons	Rainy Seasons	Dry Seasons	Rainy Seasons	Dry Seasons	Rainy Seasons
Dissolved CO_2 ($mg.L^{-1}$)	22	35,2	26,4	35,2	30,8	35,2
Nitrate ($mg.L^{-1}$)	3,22	5,96	3,61	4,72	3,03	4,06
Phosphate ($mg.L^{-1}$)	0,37	0,44	0,41	0,53	0,15	0,22

The Bun-bun River belongs to the brackish water type with salinity ranging from 5.4-7.9 ppt in the dry season and 7.2-9.48 ppt in the rainy season. Salinity increases in the part of the river that is closer to the sea. Water temperature and brightness were higher in the dry season than the wet season. In contrast, pH, salinity, dissolved CO_2, and nitrate and phosphate levels are lower in the dry season than the wet season. In the dry season, the pH is relatively more acidic than the rainy season. The location of the river which is in the mangrove forest area but has a relatively neutral pH, between 6.51-7.52, indicates the influx of sea water. Dissolved CO_2 also shows an increase from Station 1 to 3 in line with the more towards the estuary, especially in the dry season, while in the rainy season, it is in relatively the same condition between stations.

The number of phytoplankton species for each class to calculate to phytoplankton abundance in each season (Figure 2) to calculate. In the dry season, the number of phytoplankton species of Class Bacillariophyceae at Stations 1 and 2 was greater than those found at the same locations in the rainy season. In contrast, the number of species of Class Bacillariophyceae at Station 3 was less in the rainy season than in the dry season. Next, the number of species of Class Dinophyceae varied in each station and both seasons. In the dry season, Dinophyceae at Station 1 was less but at Station 3 was more than in the rainy season. Meanwhile, in the dry season the number of species of Dinophyceae class at Station 2 was the same as in the rainy season. Next, the number of species of Chlorophyceae class at each station in the dry season is more than in the rainy season.

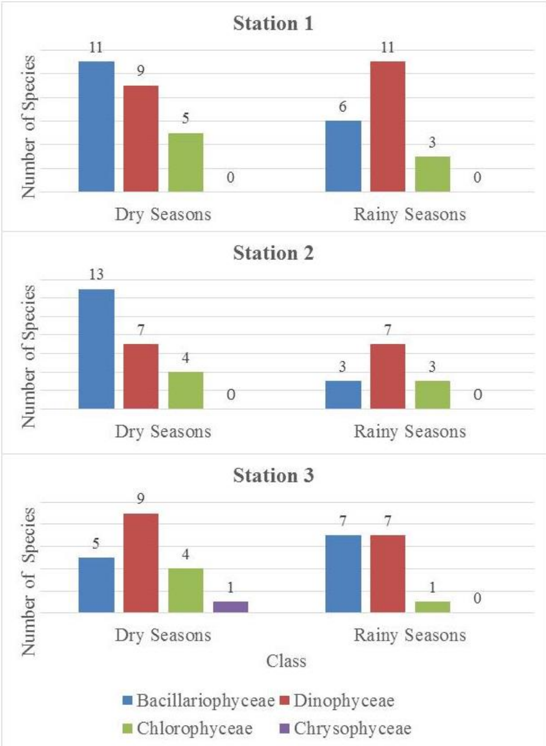

Figure 2. Description of Number of Phytoplankton Species of Each Class Found in Bun-Bun River at Three Stations and Both Seasons to Calculate Abundance

Examples of the most abundant phytoplankton species from each class can be seen in Figure 3. From the Bacillariophyceae Class, *Thalassiosira eccentrica* was found to be the most abundant at 464 $ind.L^{-1}$ in the dry season but decreased to 4 $ind.L^{-1}$ in the rainy season. *Ceratium* sp. from Class Dinophyceae was found as much as 829 $ind.L^{-1}$ in the dry season and decreased to 474 $ind.L^{-1}$ in the rainy season. *Schroderia segitera* from Class Chlorophyceae was 60 $ind.L^{-1}$ in the dry season and relatively stable at 56 $ind.L^{-1}$ in the rainy season. *Dinobryon* sp. from Class Chrysophyceae was only found in the dry season with an abundance of 1 $ind.L^{-1}$.

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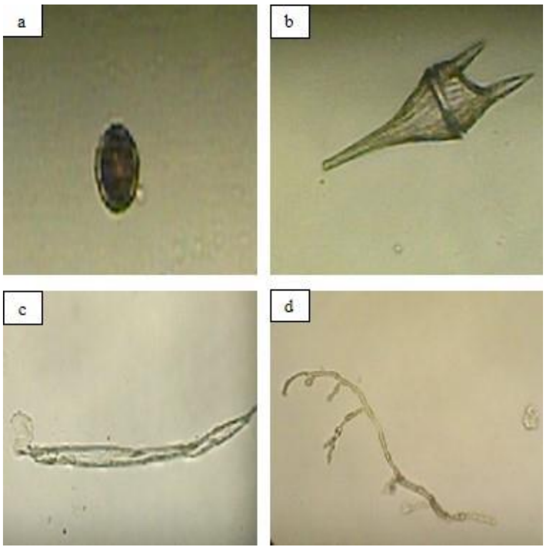

Figure 3. Images of Phytoplankton Species of Each Class in Bun-Bun River: *Thalassiosira eccentrica* of Class Bacillariophyceae (a), *Ceratium* sp. of Class Dinophyceae (b), *Schroderia segitera* of Class Chlorophyceae (c), and *Dinobryon* sp. of Class Chrysophyceae (d).

Phytoplankton abundance in the dry season was relatively higher than the rainy season (Figure 4). The highest phytoplankton abundance was at Station 3 at 3040 ind.L^{-1} in the dry season and the lowest abundance was also at Station 3 in the rainy season at 416 ind.L^{-1}. Generally, the abundance in the dry season was higher than the rainy season except at Station 1. The abundance was also seen to increase from Station 1 to Station 3 in the dry season but in the rainy season the abundance decreased from Station 1 to Station 3. Referring to Raymont (1980), the Bun-bun River has a low fertility level (oligotropic) except at Station 3 in the dry season where the fertility level increases to mesotropic.

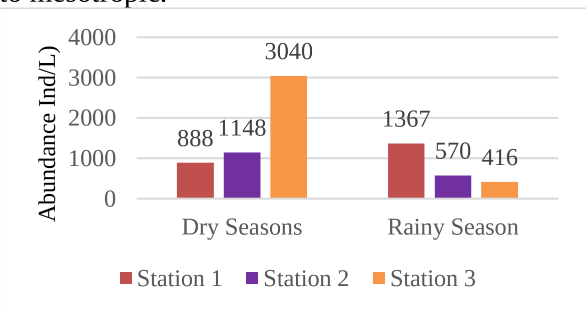

Figure 4. Phytoplankton Abundance per Station and Season in Bun-bun River

Based on the diversity index value, the phytoplankton community structure also varied between stations and seasons (Figure 5). Diversity at Stations 1 and 2 was higher in the dry season which then decreased in the rainy season. In contrast, phytoplankton species diversity was higher at Station 3 in the wet season compared to the dry season. The highest species diversity index was found at Station 3 in the wet season (1.75) and Station 1 in the dry season (1.7). Nevertheless, in all three stations and both seasons the diversity index value is still in the medium category (1≤ H' ≤3) except at Station 3 in the dry season in the low category (< 1).

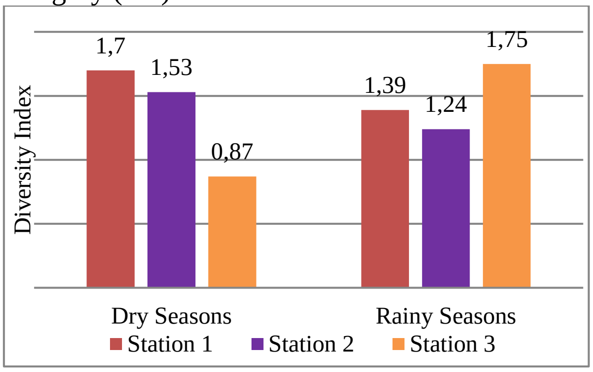

Figure 5. Phytoplankton Diversity Index in Bun-bun River at Three Stations and Both Seasons

The uniformity index of phytoplankton in Bun-bun River can be observed in Figure 6. Fluctuations in uniformity values between stations occurred in different seasons. At Station 1, phytoplankton uniformity was higher in the dry season than in the rainy season. In contrast, at Station 3 the uniformity was higher in the wet season than the dry season, while at Station 2 it was relatively stable. In both seasons, Stations 1 and 2 had moderate levels of phytoplankton community uniformity, although at Station 1 there was a decreased in uniformity in the rainy season. At Station 3 in the wet season, the uniformity of the phytoplankton community appeared to be the highest compared to other stations and seasons.

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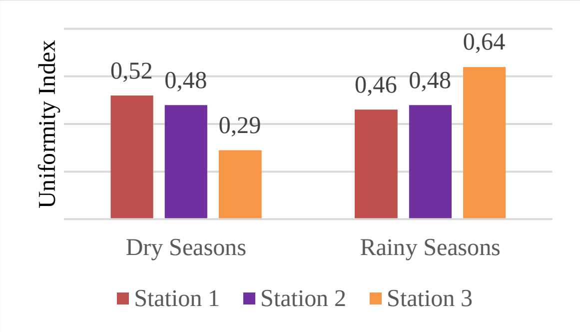

Figure 6. Phytoplankton Uniformity Index at Three Stations in Bun-bun River in the Rainy and Dry Seasons

The results of the phytoplankton dominance index measurements in the Bun-bun River also showed diverse conditions between stations. The dominance index in the dry and rainy seasons at Stations 1 and 2 fell into the medium category (0.4≤C≤0.6), while at Station 3 there was an increase in dominance from low (0.26) in the rainy season to high (0.62) in the dry season. The dominance index showed an increase from Station 1 to Station 3 in the dry season while in the rainy season Station 3 showed the lowest dominance index.

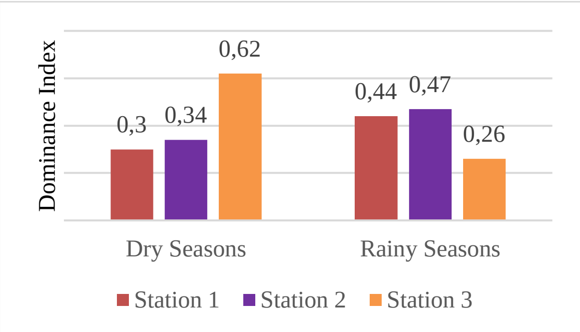

Figure 7. Phytoplankton Dominance Index at Three Stations in Bun-bun River during Dry and Rainy Season

Discussion

The Bun-bun River was characterized by brackish waters with calm currents (less than 0.1 $m.s^{-1}$) at the surface and is suitable for aquatic biota life when viewed from temperature (28.4-32.8°C), DO content (equal to more 3.7), and pH (6.51-7.56) based on PP No. 22 of 2021 and Kep. 51 MENKLH of 2004. However, the number of phytoplankton species found is still at a low to moderate level of diversity. Evita *et al.*, (2021) stated that the stability of the phytoplankton community in a stable state can be indicated by a moderate diversity value. Persulessy & Arini (2018) state that diversity is classified moderate do to the number species that occupy the area is not many species. The low diversity in Bun-bun River was supported by high dissolved CO_2 levels. Dissolved CO_2 levels that are good for organisms in the water are approximately 15 $mg.L^{-1}$ (Idrus, 2018). Dissolved CO_2 in the Bun-bun River ranges from 22-35.2 $mg.L^{-1}$ where the value in the rainy season was higher than the dry season. In waters, CO_2 can come from atmospheric diffusion, rain, groundwater, plant and animal respiration, and aerobic and anaerobic bacteria (Effendi, 2003). Dissolved CO_2 was needed by aquatic biota to help decompose organic matter by bacteria and for photosynthesis by photosynthetic organisms.

In the dry season, low diversity was found in the estuarine position, while it increased in the part of the river away from the sea. Higher diversity at sites further away from the sea was also found in the wet season, but still lower than at estuarine positions. This is most likely related to the higher mixing of seawater and river water in the rainy season so that phytoplankton migrate up the Bun-bun River estuary. The phenomenon of seawater mixing was evident from the Bun-bun River's salinity levels, which are too high for freshwater. This can also be seen from the sharp increase in diversity at the estuary position during the wet season compared to the dry season. However, the increase in diversity at Station 3 during the rainy season was not followed by a high abundance, in fact the lowest phytoplankton abundance was found at that location and time. According to Irnawati *et al.*, (2020) this is influenced by the distribution of individuals of the species. Even do there area many species in a community if the distribution is uneven then the species diversity is low.

On the other hand, low fertility can also be influenced by limited nutrient content. Nitrate and phosphate levels in the Bun-bun River are relatively low at 3.03-5.96 $mg.L^{-1}$ and 0.15-0.44 $mg.L^{-1}$, respectively. Nitrate and phosphate play a role in phytoplankton growth and metabolism. The need for nitrate and phosphate was supported by their availability in the environment so that phytoplankton growth was limited by one of the macro nutrients such as phosphorus (P), nitrogen (N), and silicon (Si), as well as micronutrients

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such as iron (Fe) (Karl, 2000; Paytan & McLaughlin, 2007; Moore *et al*., 2013). In line with Nurfadilah *et al*., (2019), parameters including phytoplankton abundance, nitrate, phosphate, brightness, pH, and temperature provide a positive correlation to primary productivity.

The low diversity in Bun-bun River is most likely due to dominance. At Station 3 in the dry season, the lowest diversity (0.87) was characterized by the highest dominance value (0.62) and the lowest uniformity value (0.29). The low diversity value illustrates that the community of organisms in these water conditions is less diverse (Novrilianty *et al*., 2022). Odum (1993) states that if uniformity is low, there tends to be dominance of one or more species in a community. In Bun-bun River, the highest number of dominance phytoplankton species at Station 3 was *Ceratium* sp. (Class Dinophyceae). *Ceratium* sp. is a species commonly found in marine waters (Nontji, 2008). *Ceratium* belongs to a group of dinoflagellates that can migrate vertically to the surface, one of which is done to increase photosynthesis in the water column integrally (Whittington *et al*., 2000). *Ceratium* sp. was also found to dominate in the waters of Bedono Village, Demak Regency, which was characterized by coastal areas with mangrove ecosystems and river flow (Gurning, Nuraini, & Suryono, 2020).

In contrast, the highest diversity value at Station 3 in the wet season (1.75) was also characterized by the lowest dominance value (0.26) and the highest uniformity value (0.64). The low dominance index value indicates that the number of individuals of each species is relatively equal and there is no particular species that dominates (Sukawati *et al*., 2018). Yuliana (2015) states that the low dominance value indicates that the phytoplankton community structure does not have species that dominate other species. The physico-chemical parameters of water are in the appropriate range so that there is no competition, and all species have the same opportunity to grow and develop properly.

Overall, Bun-bun River is a type of brackish water characterized by a phytoplankton community structure with low abundance and diversity. This feature can be caused by dominance and limiting physical and chemical factors, such as high dissolved CO_2 and salinity. The position of the Bun-bun River, which was in a mangrove forest area and has a section that empties directly into the sea, provides unique characteristics in physico-chemical factors as well as the types of phytoplankton found in it.

4. CONCLUSION

Fifty-two species of phytoplankton were found in Bun-bun River from the classes Bacillariophyceae (25 species), Dinophyceae (14 species), Chlorophyceae (12 species) and Chrysophyceae (1 species). Bun-bun River was characterized by brackish waters with low nitrate and phosphate levels and relatively high dissolved CO_2 despite DO levels of 3.7-6.3 and pH of 6.51-7.52. The Bun-bun River has low to moderate water fertility quality with abundance between 416-3040 ind.L^{-1}. Diversity in the Bun-bun River was also in the low to medium category characterized by low to high dominance and uniformity which illustrates that the phytoplankton community was in a fluctuating condition that depends on mixing with seawater.

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