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#2327 Summary

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Analysis Of Phytoplankton Abundance In Kassikebo Waters, Pangkep Regency, South Sulawesi, Indonesia

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ABSTRACT

Changes in nutrient concentrations can be caused by anthropogenic activities in coastal and marine waters. This affects the abundance of phytoplankton. The waters experiencing it are the waters of Kassikebo Pangkep, South Sulawesi, Indonesia. For this reason, research has been carried out to analyze the abundance and structure of phytoplankton communities in these waters. The results showed that the classes of phytoplankton found were Bacillariophyceae and Cyanophyceae. Species found such as Skeletonema and Detonula. The results of One Way ANOVA showed that phytoplankton abundance was not significantly different between observation stations ($p>0.05$). Changes in phytoplankton abundance are caused by pH.

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INTRODUCTION

One of the important biotic components in water is phytoplankton (Kamboj et al., 2022; Guo et al., 2019). These microorganisms are microscopic plants (Arundhathy et al., 2021; Manickam et al., 2020), hovering within the water column (Zhang et al., 2021). Its existence is very important in supporting the continuity of the role of aquatic ecosystems in supporting the life of other organisms (Otero et al., 2018), affecting aquatic productivity (Vernet et al., 2019), and determining the fertility level of waters (Tambaru et al., 2021a).

Changes in water quality, such as changes in nutrient concentrations, affect phytoplankton abundance and community structure (Van Meerssche & Pinckney, 2019). Increased nutrient concentrations can lead to increased phytoplankton abundance, leading to blooming in waters. As a result, the surface of the waters can be covered by phytoplankton bodies that experience death (Wang et al., 2018).

The presence of phytoplankton blooming causes sunlight to be blocked from penetrating the water column (Taskjelle et al., 2017). This condition causes the photosynthesis process not to run optimally. As a result, the oxygen concentration is reduced (Niu et al., 2021). This can lead to the mass death of aquatic organisms, such as fish, due to a lack of oxygen.

Other consequences can trigger changes in the phytoplankton community structure (Tan & Ransangan, 2017). One type of phytoplankton may become dominant over the other type. If the type of phytoplankton that develops is a dangerous type, such as several types in the Dynophyceae group (Lee et al., 2019), then the waters have decreased in quality. This can have a wider impact, not only on the death of fish and other organisms but also on the level of human health.

Anthropogenic activities are one of the factors that cause changes in water quality, especially changes in nutrient concentrations (Wang et al., 2018). Some anthropogenic activities such as agricultural, fishery, industrial, and household activities, produce fertilizer waste, pesticides, feed residues, and detergents, ultimately contributing to an increase in nutrients in the waters.

One of the waters affected by anthropogenic activities is the waters of Kassikebo, Pangkep, South Sulawesi, Indonesia. Of course, the quality of the waters can change. As a result, the abundance of phytoplankton may also change. It can affect the lives of other organisms. To that end, research aimed at analyzing changes in the abundance and structure of phytoplankton communities has been carried out in these waters.

RESEARCH METHODS

Time and Place of Study

The research was conducted from January to July 2022 in the waters around the port of Kassikebo Pangkep, South Sulawesi, Indonesia. Phytoplankton sample identification was carried out at the Marine Microbiology Laboratory of the Department of Marine Sciences, Faculty of Marine and Fisheries Sciences, Hasanuddin University. Based on the preliminary survey, 3 research stations were established. Station I is near the pier, Station II is close to aquaculture, Station III is close to the estuary, and Station IV (Control station) is far from residential areas.

Phytoplankton Identification

Water sampling for phytoplankton identification is carried out at each station. A total of 100 L of water was filtered using plankton net number 25. A sample of 100 mL of filtered water was put into the sample bottle. Next, preserved with 1% Lugol and then stored in a cool box. Identification of water samples containing phytoplankton is carried out in the laboratory. The phytoplankton sampling time is 10.00 – 14.00 WITA (Tambaru et al., 2021b).

Measurement of Nutrient and Oceanographic Parameters

At each station, 250 mL of water sampling was also carried out to measure nitrate and orthophosphate nutrients in the laboratory. The measurement of oceanographic parameters such as temperature, salinity, pH, and water brightness is carried out directly in the field, along with water sampling for phytoplankton identification.

Data Analysis

Analysis of differences in phytoplankton abundance by the station was analyzed using One Way ANOVA. The relationship of phytoplankton abundance to oceanographic parameters was analyzed with Pearson's Correlation.

RESULTS

There are two classes of phytoplankton found namely Bacillariophyceae and Cyanophyceae. The type of class Bacillariophyceae is the most common when compared to the species of class Cyanophyceae. The proportion of species abundance in both classes can be seen in Figure 1.

Based on the results of phytoplankton identification, 22 species were found scattered at each station. At the station I 15 species were identified, station II detected 13 species, station III recorded 14 species, and station IV had 15 species.

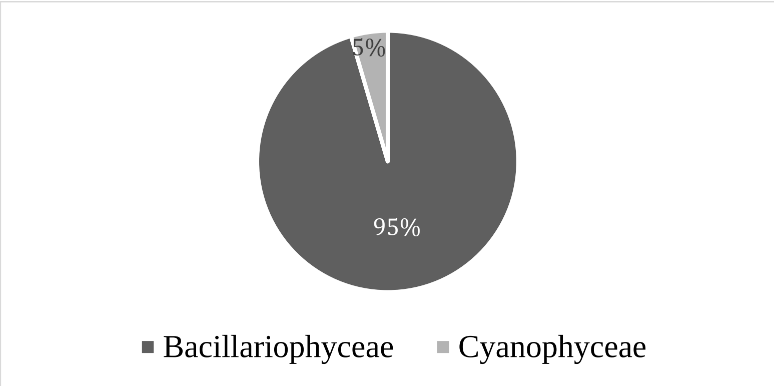

Figure 1. The proportion of Phytoplankton Class

The phytoplankton species found *are Bacteriastrum, Buddilphia, Chaetoceros, Coscinodiscus, Cylindrospermopsis, Cylindrotheca, Detonula, Ditylum, Eucampia, Flagilaria, Guinardia, Halosphaera, Hemiaulus, Isthmia, Leptocylindrus, Nitzschia, Pleurosigma, Proboscia, Rhizosolenia, Skeletonema, Thalassionema*, and *Thalassiosira*. Species that are often found are Skeletonema and Detonula. Both species are members of the Bacillariophyceae group, often found at each station.

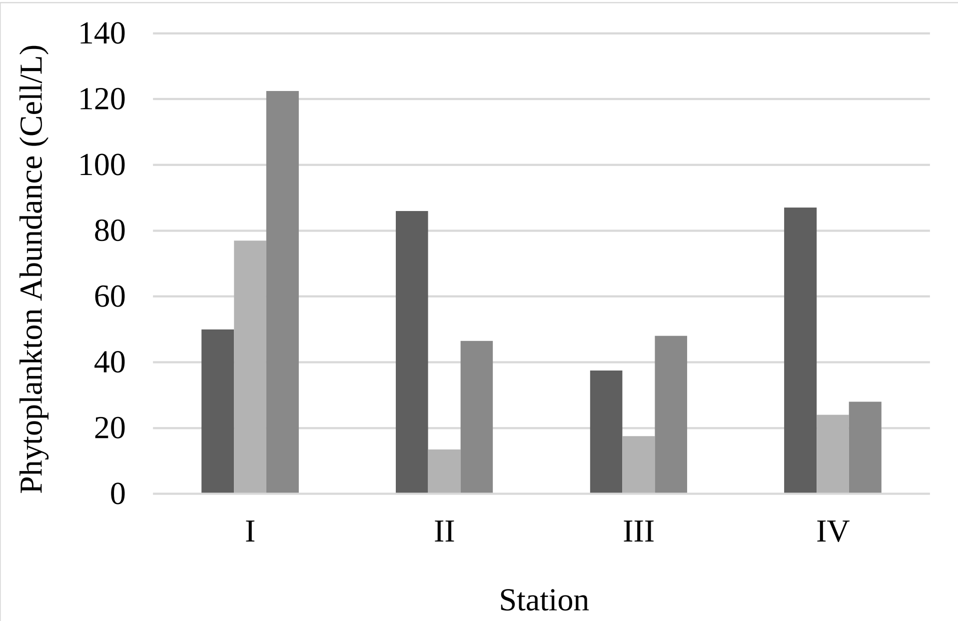

Figure 2. Abundance of Phytoplankton

The phytoplankton abundance at station I has the highest amount of abundance compared to other stations (Table 2 and Figure 2). However, based on One Way ANOVA, phytoplankton abundance is considered the same (no real difference between observation stations, $p>0.05$). Pearson's correlation was used to analyze the relationship of phytoplankton abundance to oceanographic parameters. In this analysis, phytoplankton abundance is the dependent variable, and oceanographic parameters such as temperature, salinity, pH, nitrate, and orthophosphate as independent variables.

Data on the measurement of oceanographic parameters are presented in Table 2. Measured temperature values range from 32°C - 34°C. Salinity ranges from 25 – 29 ppt. The value of the degree of acidity (pH) ranges from 7.15-7.26. Nitrates range from 0.004 – 0.062 mg/L (Table 2), and orthophosphates range from 0.008 – 0.073 mg/L.

Table 2. Results of measurement of oceanographic parameters

Station	Observation repetition	Parameter					
		The abundance of phytoplankton (Cell/L)	Temp (ºC)	Salinity (‰)	pH	Nitrate (mg/L)	Orthophosphate (mg/L)
I	1	50.0	33	25	7.15	0.051	0.019
	2	77.0	32	28	7.20	0.018	0.028
	3	122.5	33	29	7.25	0.038	0.024
II	1	86.0	33	27	7.20	0.015	0.018
	2	13.5	34	27	7.23	0.031	0.010
	3	46.5	33	28	7.23	0.061	0.017
III	1	37.5	33	27	7.20	0.034	0.022
	2	17.5	33	26	7.22	0.062	0.028
	3	48.0	34	27	7.22	0.038	0.073
IV	1	87.0	33	28	7.26	0.004	0.010
	2	24.0	32	29	7.26	0.034	0.008
	3	280	32	29	7.25	0.026	0.023

The results of Pearson's Correlation analysis showed that phytoplankton abundance only correlated with pH with a negative relationship ($r = -0.580$, $p = 0.045$) (Table 3).

Table 3. Results of Pearson correlation analysis

Correlations		
		Abundance of phytoplankton
Abundance of phytoplankton	Pearson Correlation	1
	Sig. (2-tailed)	
	N	12
Temp	Pearson Correlation	-.059
	Sig. (2-tailed)	.857
	N	12
Salinity	Pearson Correlation	-.365
	Sig. (2-tailed)	.243
	N	12
pH	Pearson Correlation	**-.580***
	Sig. (2-tailed)	**.048**
	N	**12**
Nitrate	Pearson Correlation	.091
	Sig. (2-tailed)	.779
	N	12
Orthophosphate	Pearson Correlation	-.031
	Sig. (2-tailed)	.924
	N	12
*. Correlation is significant at the 0.05 level (2-tailed).		
**. Correlation is significant at the 0.01 level (2-tailed).		

DISCUSSION

Bacillariophyceae and Cyanophyceae are the two classes found in this study. Bacillariophyceae has the most species when compared to Cyanophyceae. The same thing was also reported by Tambaru et al. (2018) in Makassar coastal waters and (Tambaru, Samawi, et al., 2021b) in Kuri Maros coastal waters. The high abundance and number of types of class Bacillariophyceae can adapt to changes in environmental conditions widely (Prelle et al., 2019). In low nutrient conditions, they still provide a rapid growth response(Li et al., 2021).

Skeletonema and Detonula are types that are often found at every station. Both types of phytoplankton are groups in the class Bacillariophyceae, often called the diatom group(Scarsini et al., 2019). Diatoms are a common and dominant component of phytoplankton in coastal waters and oceans(Harvey et al., 2019).

The frequency of the two types of phytoplankton is found because of their ability to adapt to diverse environmental conditions, ranging from upstream to river estuaries and seas (Nwe et al., 2021), from the edge to the middle of the ocean (Tibby et al., 2022). Both types are

abundant because they can withstand extreme conditions, such as low nutrient concentrations(Spilling et al., 2021). In addition, they have high reproductive power (Ajani et al., 2021), and play an important role as primary producers in waters, this is indicated by their contribution of around 20% of primary production on Earth (Vincent & Bowler, 2020).

Skeletonema is a group of diatoms with cosmopolitan properties. This type is widely distributed in coastal and marine waters. Recent research conducted in the coastal waters of Japan's Ariake has tracked several types of *Skeletonema* that evolved (Yoshida et al., 2023). They found that the occurrence of species in the Skeletonema group had different seasonal patterns. Three species of skeletonema (*S. costatum, S. menzelii, and S. tropicum*) thrive in summer, while others thrive in winter (*S. ardens, S. dohrnii/marinoi, S. grevillei*, and *S. japonicum*). The appearance of the type in the Skeletonema group suggests that they tend to adapt to different environmental conditions. Temperature is an important environmental factor in supporting its development (Canesi & Rynearson, 2016).

Just like Skeletonema, temperature also affects Detonula's life in coastal and marine waters. The process of nutrient absorption is accelerating with an increase in water temperature (Gessay & Smayda, 2016). In addition, the availability of light is another environmental factor that provides support for its development (Laws et al., 2020).

Although phytoplankton abundance was found highest at station I (Table 2 and Figure 2), phytoplankton abundance was considered the same (not significantly different) between observation stations based on variety analysis ($p>0.05$). This may happen because some physical-chemical parameters, for example, the availability of sunlight, are sufficient for phytoplankton needs in activities at all stations. Although not measured in this study, we confirmed that sunlight is widely available in the water column at all stations. This condition affects the speed of phytoplankton growth which is considered the same.

In this study, phytoplankton abundance was detected only correlated with pH with a negative relationship. This correlation can be interpreted, as changes in phytoplankton abundance occurring due to changes in pH values. The abundance of phytoplankton will decrease with the memory of the pH value, and vice versa, up to a certain pH value.

The degree of acidity (pH) influences plant life and aquatic animals. This parameter is often used as a clue to express the good or bad quality of water. For phytoplankton, pH affects the absorption of carbon dioxide in water (Gazeau et al., 2021). Under low pH conditions, the ability of phytoplankton is reduced to absorb carbon dioxide. As a result, the process of photosynthesis does not run perfectly, and the formation of food reserves decreases.

Changes in pH value affect the physiological processes of algae including phytoplankton (Raven et al., 2020). This is a driving factor for the development of several types of harmful phytoplankton (HABs) in the waters. In acidic waters with a pH of less than 6, organisms that feed fish, in this case, phytoplankton, cannot live well.

A study on pH has been reported by (Thoisen et al., 2015). In his observation, the pH value of water in acidic conditions influences decreasing the growth rate of phytoplankton communities. In addition, it exerts an influence on changes in colony size and chain length of selected species. In other studies, the effect of pH on the growth of several types of cyanobacteria and diatoms has also been observed. The results showed that the relative growth became low under acidic pH conditions (Rai & Rajashekhar, 2016).

CONCLUSION

Bacillariophyceae and Cyanophyceae are two classes of phytoplankton found in this study. Bacillariophyceae have more numbers and types when compared to the number and type of class Cyanophyceae. The types that are often found are Skeletonema and Detonula. Both types of phytoplankton are a group of the class Bacillariophyceae. The abundance of

phytoplankton at each station was no difference between observation stations. Changes in phytoplankton abundance are due to changes in pH.

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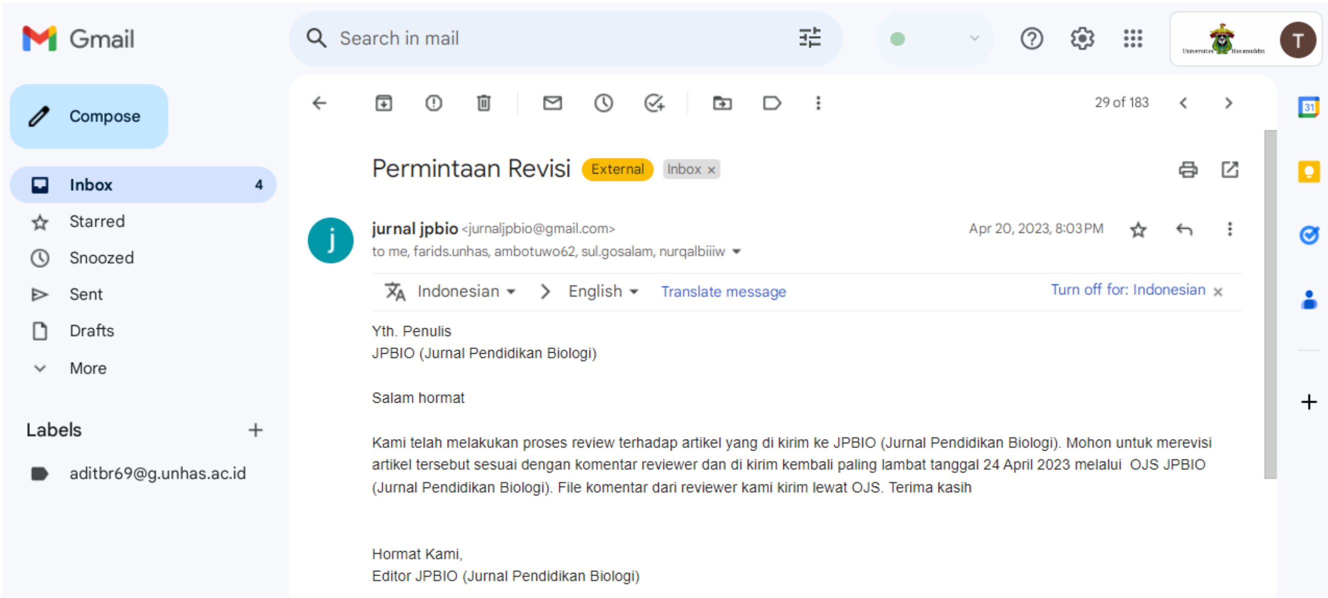

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#2327 Review

SUMMARY REVIEW EDITING

Submission

Authors	Rahmadi Tambaru, Muh Farid Samawi, Ambo Tuwo, Sulaiman Gosalam, Nur Qalbi Mujahidah
Title	Analysis of phytoplankton abundance in kassikebo waters, pangkep regency, south sulawesi, indonesia
Section	Articles
Editor	Dr. Yakobus Bustami, M.Pd.

Peer Review

Round 1

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Analysis of Phytoplankton Abundance in Kassikebo Waters, Pangkep Regency, South Sulawesi, Indonesia

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ABSTRACT

Changes in nutrient concentrations can be caused by anthropogenic activities in coastal and marine waters. This affects the abundance of phytoplankton. The waters experiencing it are the waters of Kassikebo Pangkep, South Sulawesi, Indonesia. For this reason, research has been carried out to analyze the abundance and structure of phytoplankton communities in these waters. The results showed that the classes of phytoplankton found were Bacillariophyceae and Cyanophyceae. Species found such as Skeletonema and Detonula. The results of One Way ANOVA showed that phytoplankton abundance was not significantly different between observation stations ($p>0.05$). Changes in phytoplankton abundance are caused by pH.

Citation:

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INTRODUCTION

One of the important biotic components in water is phytoplankton (Kamboj et al., 2022; Guo et al., 2019). These microorganisms are microscopic plants (Arundhathy et al., 2021; Manickam et al., 2020), hovering within the water column (Zhang et al., 2021). Its existence is very important in supporting the continuity of the role of aquatic ecosystems in supporting the life of other organisms (Otero et al., 2018), affecting aquatic productivity (Vernet et al., 2019), and determining the fertility level of waters (Tambaru et al., 2021a).

Changes in water quality, such as changes in nutrient concentrations, affect phytoplankton abundance and community structure (Van Meerssche & Pinckney, 2019). Increased nutrient concentrations can lead to increased phytoplankton abundance, leading to blooming in waters. As a result, the surface of the waters can be covered by phytoplankton bodies that experience death (Wang et al., 2018).

The presence of phytoplankton blooming causes sunlight to be blocked from penetrating the water column (Taskjelle et al., 2017). This condition causes the photosynthesis process not

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Other consequences can trigger changes in the phytoplankton community structure (Tan & Ransangan, 2017). One type of phytoplankton may become dominant over the other type. If the type of phytoplankton that develops is a dangerous type, such as several types in the Dynophyceae group (Lee et al., 2019), then the waters have decreased in quality. This can have a wider impact, not only on the death of fish and other organisms but also on the level of human health.

Anthropogenic activities are one of the factors that cause changes in water quality, especially changes in nutrient concentrations (Wang et al., 2018). Some anthropogenic activities such as agricultural, fishery, industrial, and household activities, produce fertilizer waste, pesticides, feed residues, and detergents, ultimately contributing to an increase in nutrients in the waters.

One of the waters affected by anthropogenic activities is the waters of Kassikebo, Pangkep, South Sulawesi, Indonesia. Of course, the quality of the waters can change. As a result, the abundance of phytoplankton may also change. It can affect the lives of other organisms. To that end, research aimed at analyzing changes in the abundance and structure of phytoplankton communities has been carried out in these waters.

RESEARCH METHODS

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Time and Place of Study

The research was conducted from January to July 2022 in the waters around the port of Kassikebo Pangkep, South Sulawesi, Indonesia. Phytoplankton sample identification was carried out at the Marine Microbiology Laboratory of the Department of Marine Sciences, Faculty of Marine and Fisheries Sciences, Hasanuddin University. Based on the preliminary survey, 3 research stations were established. Station I is near the pier, Station II is close to aquaculture, Station III is close to the estuary, and Station IV (Control station) is far from residential areas.

Phytoplankton Identification

Water sampling for phytoplankton identification is carried out at each station. A total of 100 L of water was filtered using plankton net number 25. A sample of 100 mL of filtered water was put into the sample bottle. Next, preserved with 1% Lugol and then stored in a cool box. Identification of water samples containing phytoplankton is carried out in the laboratory. The phytoplankton sampling time is 10.00 – 14.00 WITA (Tambaru et al., 2021b).

Measurement of Nutrient and Oceanographic Parameters

At each station, 250 mL of water sampling was also carried out to measure nitrate and orthophosphate nutrients in the laboratory. The measurement of oceanographic parameters such as temperature, salinity, pH, and water brightness is carried out directly in the field, along with water sampling for phytoplankton identification.

Data Analysis

Analysis of differences in phytoplankton abundance by the station was analyzed using One Way ANOVA. The relationship of phytoplankton abundance to oceanographic parameters was analyzed with Pearson's Correlation.

RESULTS

There are two classes of phytoplankton found namely Bacillariophyceae and Cyanophyceae. The type of class Bacillariophyceae is the most common when compared to the species of class Cyanophyceae. The proportion of species abundance in both classes can be seen in Figure 1.

Based on the results of phytoplankton identification, 22 species were found scattered at each station. At the station I 15 species were identified, station II detected 13 species, station III recorded 14 species, and station IV had 15 species.

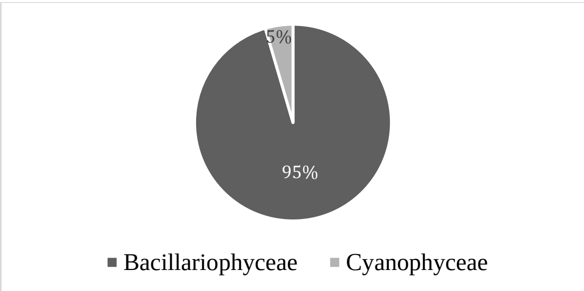

Figure 1. The proportion of Phytoplankton Class

The phytoplankton species found *are Bacteriastrum, Buddilphia, Chaetoceros, Coscinodiscus, Cylindrospermopsis, Cylindrotheca, Detonula, Ditylum, Eucampia, Flagilaria, Guinardia, Halosphaera, Hemiaulus, Isthmia, Leptocylindrus, Nitzschia, Pleurosigma, Proboscia, Rhizosolenia, Skeletonema, Thalassionema*, and *Thalassiosira*. Species that are often found are Skeletonema and Detonula. Both species are members of the Bacillariophyceae group, often found at each station.

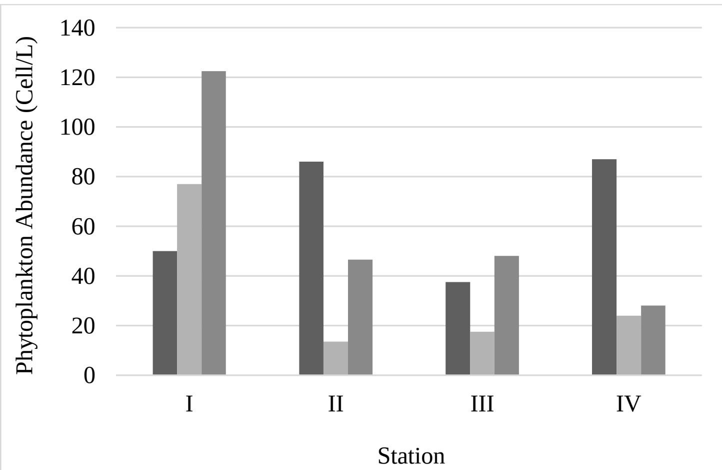

Figure 2. Abundance of Phytoplankton

The phytoplankton abundance at station I has the highest amount of abundance compared to other stations (Table 2 and Figure 2). However, based on One Way ANOVA, phytoplankton abundance is considered the same (no real difference between observation stations, $p>0.05$). Pearson's correlation was used to analyze the relationship of phytoplankton abundance to oceanographic parameters. In this analysis, phytoplankton abundance is the dependent variable, and oceanographic parameters such as temperature, salinity, pH, nitrate, and orthophosphate as independent variables.

Data on the measurement of oceanographic parameters are presented in Table 2. Measured temperature values range from 32°C - 34°C. Salinity ranges from 25 – 29 ppt. The value of the degree of acidity (pH) ranges from 7.15-7.26. Nitrates range from 0.004 – 0.062 mg/L (Table 2), and orthophosphates range from 0.008 – 0.073 mg/L.

Table 2. Results of measurement of oceanographic parameters

Station	Observation repetition	Parameter					
		The abundance of phytoplankton (Cell/L)	Temp (ºC)	Salinity (‰)	pH	Nitrate (mg/L)	Orthophosphate (mg/L)
I	1	50.0	33	25	7.15	0.051	0.019
	2	77.0	32	28	7.20	0.018	0.028
	3	122.5	33	29	7.25	0.038	0.024
II	1	86.0	33	27	7.20	0.015	0.018
	2	13.5	34	27	7.23	0.031	0.010
	3	46.5	33	28	7.23	0.061	0.017
III	1	37.5	33	27	7.20	0.034	0.022
	2	17.5	33	26	7.22	0.062	0.028
	3	48.0	34	27	7.22	0.038	0.073
IV	1	87.0	33	28	7.26	0.004	0.010
	2	24.0	32	29	7.26	0.034	0.008
	3	280	32	29	7.25	0.026	0.023

The results of Pearson's Correlation analysis showed that phytoplankton abundance only correlated with pH with a negative relationship ($r = -0.580$, $p = 0.045$) (Table 3).

Table 3. Results of Pearson correlation analysis

Correlations

		Abundance of phytoplankton
Abundance of phytoplankton	Pearson Correlation	1
	Sig. (2-tailed)	
	N	12
Temp	Pearson Correlation	-.059
	Sig. (2-tailed)	.857
	N	12
Salinity	Pearson Correlation	-.365
	Sig. (2-tailed)	.243
	N	12
pH	Pearson Correlation	**-.580***
	Sig. (2-tailed)	**.048**
	N	**12**
Nitrate	Pearson Correlation	.091
	Sig. (2-tailed)	.779
	N	12
Orthophosphate	Pearson Correlation	-.031
	Sig. (2-tailed)	.924
	N	12

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

Bacillariophyceae and Cyanophyceae are the two classes found in this study. Bacillariophyceae has the most species when compared to Cyanophyceae. The same thing was also reported by Tambaru et al. (2018) in Makassar coastal waters and (Tambaru, Samawi, et al., 2021b) in Kuri Maros coastal waters. The high abundance and number of types of class Bacillariophyceae can adapt to changes in environmental conditions widely (Prelle et al., 2019). In low nutrient conditions, they still provide a rapid growth response(Li et al., 2021).

Skeletonema and Detonula are types that are often found at every station. Both types of phytoplankton are groups in the class Bacillariophyceae, often called the diatom group(Scarsini et al., 2019). Diatoms are a common and dominant component of phytoplankton in coastal waters and oceans(Harvey et al., 2019).

The frequency of the two types of phytoplankton is found because of their ability to adapt to diverse environmental conditions, ranging from upstream to river estuaries and seas (Nwe et al., 2021), from the edge to the middle of the ocean (Tibby et al., 2022). Both types are

abundant because they can withstand extreme conditions, such as low nutrient concentrations(Spilling et al., 2021). In addition, they have high reproductive power (Ajani et al., 2021), and play an important role as primary producers in waters, this is indicated by their contribution of around 20% of primary production on Earth (Vincent & Bowler, 2020).

Skeletonema is a group of diatoms with cosmopolitan properties. This type is widely distributed in coastal and marine waters. Recent research conducted in the coastal waters of Japan's Ariake has tracked several types of *Skeletonema* that evolved (Yoshida et al., 2023). They found that the occurrence of species in the Skeletonema group had different seasonal patterns. Three species of skeletonema (*S. costatum, S. menzelii, and S. tropicum*) thrive in summer, while others thrive in winter (*S. ardens, S. dohrnii/marinoi, S. grevillei*, and *S. japonicum*). The appearance of the type in the Skeletonema group suggests that they tend to adapt to different environmental conditions. Temperature is an important environmental factor in supporting its development (Canesi & Rynearson, 2016).

Just like Skeletonema, temperature also affects Detonula's life in coastal and marine waters. The process of nutrient absorption is accelerating with an increase in water temperature (Gessay & Smayda, 2016). In addition, the availability of light is another environmental factor that provides support for its development (Laws et al., 2020).

Although phytoplankton abundance was found highest at station I (Table 2 and Figure 2), phytoplankton abundance was considered the same (not significantly different) between observation stations based on variety analysis ($p>0.05$). This may happen because some physical-chemical parameters, for example, the availability of sunlight, are sufficient for phytoplankton needs in activities at all stations. Although not measured in this study, we confirmed that sunlight is widely available in the water column at all stations. This condition affects the speed of phytoplankton growth which is considered the same.

In this study, phytoplankton abundance was detected only correlated with pH with a negative relationship. This correlation can be interpreted, as changes in phytoplankton abundance occurring due to changes in pH values. The abundance of phytoplankton will decrease with the memory of the pH value, and vice versa, up to a certain pH value.

The degree of acidity (pH) influences plant life and aquatic animals. This parameter is often used as a clue to express the good or bad quality of water. For phytoplankton, pH affects the absorption of carbon dioxide in water (Gazeau et al., 2021). Under low pH conditions, the ability of phytoplankton is reduced to absorb carbon dioxide. As a result, the process of photosynthesis does not run perfectly, and the formation of food reserves decreases.

Changes in pH value affect the physiological processes of algae including phytoplankton (Raven et al., 2020). This is a driving factor for the development of several types of harmful phytoplankton (HABs) in the waters. In acidic waters with a pH of less than 6, organisms that feed fish, in this case, phytoplankton, cannot live well.

A study on pH has been reported by (Thoisen et al., 2015). In his observation, the pH value of water in acidic conditions influences decreasing the growth rate of phytoplankton communities. In addition, it exerts an influence on changes in colony size and chain length of selected species. In other studies, the effect of pH on the growth of several types of cyanobacteria and diatoms has also been observed. The results showed that the relative growth became low under acidic pH conditions (Rai & Rajashekhar, 2016).

CONCLUSION

Bacillariophyceae and Cyanophyceae are two classes of phytoplankton found in this study. Bacillariophyceae have more numbers and types when compared to the number and type of class Cyanophyceae. The types that are often found are Skeletonema and Detonula. Both types of phytoplankton are a group of the class Bacillariophyceae. The abundance of

phytoplankton at each station was no difference between observation stations. Changes in phytoplankton abundance are due to changes in pH.

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Analysis of Phytoplankton Abundance in Kassikebo Waters, Pangkep Regency, South Sulawesi, Indonesia

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ABSTRACT

Changes in nutrient concentrations can be caused by anthropogenic activities in coastal and marine waters. This affects the abundance of phytoplankton. The waters experiencing it are the waters of Kassikebo Pangkep, South Sulawesi, Indonesia. For this reason, research has been carried out to analyze the abundance and structure of phytoplankton communities in these waters, from January to July 2022. To identify phytoplankton, 100 L of seawater samples were filtered, which were taken at each station. The results of that water filter, identified in the laboratory. The results showed that the classes of phytoplankton found were Bacillariophyceae and Cyanophyceae. Species found such as Skeletonema and Detonula. The results of One Way ANOVA showed that phytoplankton abundance was not significantly different between observation stations (p>0.05). Changes in phytoplankton abundance are caused by pH.

Citation:

INTRODUCTION

One of the important biotic components in water is phytoplankton (Kamboj et al., 2022; Guo et al., 2019). These microorganisms are microscopic plants (Arundhathy et al., 2021; Manickam et al., 2020), hovering within the water column (Zhang et al., 2021). Its existence is very important in supporting the continuity of the role of aquatic ecosystems in supporting the life of other organisms (Otero et al., 2018), affecting aquatic productivity (Vernet et al., 2019), and determining the fertility level of waters (Tambaru et al., 2021a).

Changes in water quality, such as changes in nutrient concentrations, affect phytoplankton abundance and community structure (Van Meerssche & Pinckney, 2019). Increased nutrient concentrations can lead to increased phytoplankton abundance, leading to blooming in waters. As a result, the surface of the waters can be covered by phytoplankton bodies that experience death (Wang et al., 2018).

The presence of phytoplankton blooming causes sunlight to be blocked from penetrating the water column (Taskjelle et al., 2017). This condition causes the photosynthesis process not to run optimally. As a result, the oxygen concentration is reduced (Niu et al., 2021). This can lead to the mass death of aquatic organisms, such as fish, due to a lack of oxygen.

Other consequences can trigger changes in the phytoplankton community structure (Tan & Ransangan, 2017). One type of phytoplankton may become dominant over the other type. If the type of phytoplankton that develops is a dangerous type, such as several types in the Dynophyceae group (Lee et al., 2019), then the waters have decreased in quality. This can have a wider impact, not only on the death of fish and other organisms but also on the level of human health.

Research conducted on the west coast of South Sulawesi, Indonesia by (Tambaru et al., 2021a), and on the south coast of South Sulawesi, Indonesia by (Tambaru, 2022) has reported on the emergence of potentially dangerous phytoplankton species. Similarly, research conducted by (Mujib et al., 2015) in the waters of Makassar, South Sulawesi, Indonesia. However, the abundance of potentially dangerous phytoplankton types is still very low when compared to good quality phytoplankton types.

Anthropogenic activities are one of the factors that cause changes in water quality, especially changes in nutrient concentrations (Wang et al., 2018). Some anthropogenic activities such as agricultural, fishery, industrial, and household activities, produce fertilizer waste, pesticides, feed residues, and detergents, ultimately contributing to an increase in nutrients in the waters.

One of the waters affected by anthropogenic activities is the waters of Kassikebo, Pangkep, South Sulawesi, Indonesia. Of course, the quality of the waters can change. As a result, the abundance of phytoplankton may also change. It can affect the lives of other organisms. To that end, research aimed at analyzing changes in the abundance and structure of phytoplankton communities has been carried out in these waters. This research is the latest research on this water area.

RESEARCH METHODS

Time and Place of Study

The research was conducted from January to July 2022 in the waters around the port of Kassikebo Pangkep, South Sulawesi, Indonesia. Phytoplankton sample identification was carried out at the Marine Microbiology Laboratory of the Department of Marine Sciences, Faculty of Marine and Fisheries Sciences, Hasanuddin University. Based on the preliminary survey, 3 research stations were established. Station I is near the pier, Station II is close to aquaculture, Station III is close to the estuary, and Station IV (Control station) is far from residential areas.

Research Design

This research is a survey research, which is research whose observations are carried out on a number of characteristics (variables) in research subjects directly in the field. In this study, the research design applied was quantitative research.

Phytoplankton Identification

Water sampling for phytoplankton identification is carried out at each station. A total of 100 L of water was filtered using plankton net number 25. A sample of 100 mL of filtered water was put into the sample bottle. Next, preserved with 1% Lugol and then stored in a cool box. Identification of water samples containing phytoplankton is carried out in the laboratory. The phytoplankton sampling time is 10.00 – 14.00 WITA (Tambaru et al., 2021b).

Measurement of Nutrient and Oceanographic Parameters

At each station, 250 mL of water sampling was also carried out to measure nitrate and orthophosphate nutrients in the laboratory. The measurement of oceanographic parameters such as temperature, salinity, pH, and water brightness is carried out directly in the field, along with water sampling for phytoplankton identification.

Data Analysis

Analysis of differences in phytoplankton abundance by the station was analyzed using One Way ANOVA. The relationship of phytoplankton abundance to oceanographic parameters was analyzed with Pearson's Correlation.

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RESULTS

There are two classes of phytoplankton found namely Bacillariophyceae and Cyanophyceae. The type of class Bacillariophyceae is the most common when compared to the species of class Cyanophyceae. The proportion of species abundance in both classes can be seen in Figure 1.

Based on the results of phytoplankton identification, 22 species were found scattered at each station. At the station I 15 species were identified, station II detected 13 species, station III recorded 14 species, and station IV had 15 species.

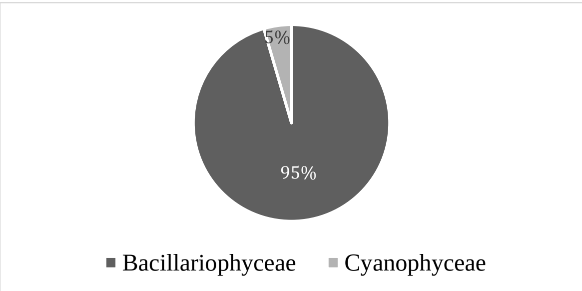

Figure 1. The proportion of Phytoplankton Class

The phytoplankton species found *are Bacteriastrum, Buddilphia, Chaetoceros, Coscinodiscus, Cylindrospermopsis, Cylindrotheca, Detonula, Ditylum, Eucampia, Flagilaria, Guinardia, Halosphaera, Hemiaulus, Isthmia, Leptocylindrus, Nitzschia, Pleurosigma, Proboscia, Rhizosolenia, Skeletonema, Thalassionema*, and *Thalassiosira*. Species that are often found are Skeletonema and Detonula. Both species are members of the Bacillariophyceae group, often found at each station.

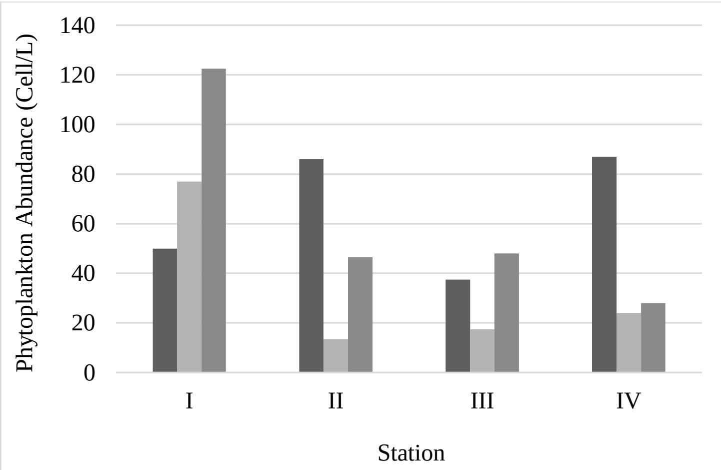

Figure 2. Abundance of Phytoplankton

The phytoplankton abundance at station I has the highest amount of abundance compared to other stations (Table 2 and Figure 2). However, based on One Way ANOVA, phytoplankton abundance is considered the same (no real difference between observation stations, $p>0.05$). Pearson's correlation was used to analyze the relationship of phytoplankton abundance to oceanographic parameters. In this analysis, phytoplankton abundance is the dependent variable, and oceanographic parameters such as temperature, salinity, pH, nitrate, and orthophosphate as independent variables.

Data on the measurement of oceanographic parameters are presented in Table 2. Measured temperature values range from 32°C - 34°C. Salinity ranges from 25 – 29 ppt. The value of the degree of acidity (pH) ranges from 7.15-7.26. Nitrates range from 0.004 – 0.062 mg/L (Table 2), and orthophosphates range from 0.008 – 0.073 mg/L.

Table 2. Results of measurement of oceanographic parameters

Station	Observation repetition	Parameter					
		The abundance of phytoplankton (Cell/L)	Temp (ºC)	Salinity (‰)	pH	Nitrate (mg/L)	Orthophosphate (mg/L)
I	1	50.0	33	25	7.15	0.051	0.019
	2	77.0	32	28	7.20	0.018	0.028
	3	122.5	33	29	7.25	0.038	0.024
II	1	86.0	33	27	7.20	0.015	0.018
	2	13.5	34	27	7.23	0.031	0.010
	3	46.5	33	28	7.23	0.061	0.017
III	1	37.5	33	27	7.20	0.034	0.022
	2	17.5	33	26	7.22	0.062	0.028
	3	48.0	34	27	7.22	0.038	0.073
IV	1	87.0	33	28	7.26	0.004	0.010

2	24.0	32	29	7.26	0.034	0.008
3	280	32	29	7.25	0.026	0.023

The results of Pearson's Correlation analysis showed that phytoplankton abundance only correlated with pH with a negative relationship (r = -0.580, p = 0.045) (Table 3).

Table 3. Results of Pearson correlation analysis

Correlations		
		Abundance of phytoplankton
Abundance of phytoplankton	Pearson Correlation	1
	Sig. (2-tailed)	
	N	12
Temp	Pearson Correlation	-.059
	Sig. (2-tailed)	.857
	N	12
Salinity	Pearson Correlation	-.365
	Sig. (2-tailed)	.243
	N	12
pH	Pearson Correlation	**-.580***
	Sig. (2-tailed)	**.048**
	N	**12**
Nitrate	Pearson Correlation	.091
	Sig. (2-tailed)	.779
	N	12
Orthophosphate	Pearson Correlation	-.031
	Sig. (2-tailed)	.924
	N	12

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

Bacillariophyceae and Cyanophyceae are the two classes found in this study. Bacillariophyceae has the most species when compared to Cyanophyceae. The same thing was also reported by Tambaru et al. (2018) in Makassar coastal waters and (Tambaru, Samawi, et al., 2021b) in Kuri Maros coastal waters. The high abundance and number of types of class Bacillariophyceae can adapt to changes in environmental conditions widely (Prelle et al., 2019). In low nutrient conditions, they still provide a rapid growth response(Li et al., 2021).

Skeletonema and Detonula are types that are often found at every station. Both types of phytoplankton are groups in the class Bacillariophyceae, often called the diatom group(Scarsini et al., 2019). Diatoms are a common and dominant component of phytoplankton in coastal waters and oceans(Harvey et al., 2019).

The frequency of the two types of phytoplankton is found because of their ability to adapt to diverse environmental conditions, ranging from upstream to river estuaries and seas (Nwe et al., 2021), from the edge to the middle of the ocean (Tibby et al., 2022). Both types are abundant because they can withstand extreme conditions, such as low nutrient concentrations(Spilling et al., 2021). In addition, they have high reproductive power (Ajani et al., 2021), and play an important role as primary producers in waters, this is indicated by their contribution of around 20% of primary production on Earth (Vincent & Bowler, 2020).

Skeletonema is a group of diatoms with cosmopolitan properties. This type is widely distributed in coastal and marine waters. Recent research conducted in the coastal waters of Japan's Ariake has tracked several types of *Skeletonema* that evolved (Yoshida et al., 2023). They found that the occurrence of species in the Skeletonema group had different seasonal patterns. Three species of skeletonema (*S. costatum, S. menzelii, and S. tropicum*) thrive in summer, while others thrive in winter (*S. ardens, S. dohrnii/marinoi, S. grevillei*, and *S. japonicum*). The appearance of the type in the Skeletonema group suggests that they tend to adapt to different environmental conditions. Temperature is an important environmental factor in supporting its development (Canesi & Rynearson, 2016).

Just like Skeletonema, temperature also affects Detonula's life in coastal and marine waters. The process of nutrient absorption is accelerating with an increase in water temperature (Gessay & Smayda, 2016). In addition, the availability of light is another environmental factor that provides support for its development (Laws et al., 2020).

Although phytoplankton abundance was found highest at station I (Table 2 and Figure 2), phytoplankton abundance was considered the same (not significantly different) between observation stations based on variety analysis ($p>0.05$). This may happen because some physical-chemical parameters, for example, the availability of sunlight, are sufficient for phytoplankton needs in activities at all stations. Although not measured in this study, we confirmed that sunlight is widely available in the water column at all stations. This condition affects the speed of phytoplankton growth which is considered the same.

In this study, phytoplankton abundance was detected only correlated with pH with a negative relationship. This correlation can be interpreted, as changes in phytoplankton abundance occurring due to changes in pH values. The abundance of phytoplankton will decrease with the memory of the pH value, and vice versa, up to a certain pH value.

The degree of acidity (pH) influences plant life and aquatic animals. This parameter is often used as a clue to express the good or bad quality of water. For phytoplankton, pH affects the absorption of carbon dioxide in water (Gazeau et al., 2021). Under low pH conditions, the ability of phytoplankton is reduced to absorb carbon dioxide. As a result, the process of photosynthesis does not run perfectly, and the formation of food reserves decreases.

Changes in pH value affect the physiological processes of algae including phytoplankton (Raven et al., 2020). This is a driving factor for the development of several types of harmful phytoplankton (HABs) in the waters. In acidic waters with a pH of less than 6, organisms that feed fish, in this case, phytoplankton, cannot live well.

A study on pH has been reported by (Thoisen et al., 2015). In his observation, the pH value of water in acidic conditions influences decreasing the growth rate of phytoplankton communities. In addition, it exerts an influence on changes in colony size and chain length of selected species. In other studies, the effect of pH on the growth of several types of cyanobacteria and diatoms has also been observed. The results showed that the relative growth became low under acidic pH conditions (Rai & Rajashekhar, 2016).

CONCLUSION

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Bacillariophyceae and Cyanophyceae are two classes of phytoplankton found in this study. Bacillariophyceae have more numbers and types when compared to the number and type of class Cyanophyceae. The types that are often found are Skeletonema and Detonula. Both types of phytoplankton are a group of the class Bacillariophyceae. The abundance of phytoplankton at each station was no difference between observation stations. Changes in phytoplankton abundance are due to changes in pH.

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4. RESPONS KE REVIEWER A (Review Pertama)

Response untuk Reviewer A

Jurnal Pendidikan Biologi (JPBIO)

Analysis of Phytoplankton Abundance in Kassikebo Waters, Pangkep Regency, South Sulawesi, Indonesia

Korespondensi : aditbr69@unhas.ac.id

Isi	Komentar Reviewer	Revisi
ABSTRACT	Di bagian abstrak, ungkapkan juga metode penelitian yang digunakan, setelah menungkapkan tujuan penelitian	• Sudah ditambahkan di bagian Abstract :....from January to July 2022. To identify phytoplankton, 100 L of seawater samples were filtered, which were taken at each station. The results of that water filter, identified in the laboratory.
INTRODUCTION	Pada bagian pendahuluan, ungkapkan juga keterbaharuan daru penelitian ini, dengan membandingkan penelitian ini dengan penelitian sebelumnya dan dimana letak perbedaannya sehingga akan kelihatan keterbaharuannya	• Sudah ditambahkan di Pendahuluan : Aline ke-5/Hal 2 ….. Research conducted on the west coast of South Sulawesi, Indonesia by (Tambaru et al., 2021a), and on the south coast of South Sulawesi, Indonesia by (Tambaru, 2022) has reported on the emergence of potentially dangerous phytoplankton species. Similarly, research conducted by (Mujib et al., 2015) in the waters of Makassar, South Sulawesi, Indonesia. However, the abundance of potentially dangerous phytoplankton types is still very low when compared to good quality phytoplankton types. • Akhir alinea ke-7/Hal 2 (keterbaruan berdasarkan lokasi): This research is the latest research on this water area.
RESEARCH METHODS	Rancangan penelitian seperti apa?	• Sudah ditambahkan Research Design (Hal 2): This research is a survey research, which is research whose observations are carried out on a number of characteristics (variables) in research subjects directly in the field. In this study, the research design applied was quantitative research.
ACKNOWLEDGMENT	Dalam satu paragraph tidak boleh hanya satu kalimat, untuk itu perlu ditambah lagi ucapan terima kasih ini kepada siapa saja	• Sudah direvisi (Hal 7) : The author's gratitude is conveyed to the Dean and Head of Department of Marine Science at the Faculty of Marine Sciences and Fisheries, Hasanuddin University, as well as the Leaders and Staff of the Chemical Oceanography Laboratory of the Department of Marine Sciences, Faculty of Marine Sciences and

	yang telah memberikan kontribusi dalam penelitian ini	Fisheries, Hasanuddin University, for their support and assistance in the implementation of this research.
REFERENCES	• Penambahan Sitasi	Mujib, A. S., Damar, A., & Wardiatno, Y. (2015). Spatial distribution of planktonic dinoflagellate in Makassar waters, South Sulawesi. *Jurnal Ilmu Dan Teknologi Kelautan Tropis*, *7*(2). Retrieved from https://jurnal.ipb.ac.id/index.php/jurnalikt/article/view/11033 Tambaru, R. (2022). Potentially harmful phytoplankton species In The Southern Part of West Coastal Waters of South Sulawesi. *JURNAL AGRIKAN (Agribisnis Perikanan)*, *15*(2), 453–459. Retrieved from https://www.jurnal.ummu.ac.id/index.php/agrikan/article/view/1258

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Analysis of Phytoplankton Abundance in Kassikebo Waters, Pangkep Regency, South Sulawesi, Indonesia

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ABSTRACT

Changes in nutrient concentrations can be caused by anthropogenic activities in coastal and marine waters. This affects the abundance of phytoplankton. The waters experiencing it are the waters of Kassikebo Pangkep, South Sulawesi, Indonesia. For this reason, research has been carried out to analyze the abundance and structure of phytoplankton communities in these waters, from January to July 2022. To identify phytoplankton, 100 L of seawater samples were filtered, which were taken at each station. The results of that water filter, identified in the laboratory. The results showed that the classes of phytoplankton found were Bacillariophyceae and Cyanophyceae. Species found such as Skeletonema and Detonula. The results of One Way ANOVA showed that phytoplankton abundance was not significantly different between observation stations (p>0.05). Changes in phytoplankton abundance are caused by pH.

Citation:

INTRODUCTION

One of the important biotic components in water is phytoplankton (Kamboj et al., 2022; Guo et al., 2019). These microorganisms are microscopic plants (Arundhathy et al., 2021; Manickam et al., 2020), hovering within the water column (Zhang et al., 2021). Its existence is very important in supporting the continuity of the role of aquatic ecosystems in supporting the life of other organisms (Otero et al., 2018), affecting aquatic productivity (Vernet et al., 2019), and determining the fertility level of waters (Tambaru et al., 2021a).

Changes in water quality, such as changes in nutrient concentrations, affect phytoplankton abundance and community structure (Van Meerssche & Pinckney, 2019). Increased nutrient concentrations can lead to increased phytoplankton abundance, leading to blooming in waters. As a result, the surface of the waters can be covered by phytoplankton bodies that experience death (Wang et al., 2018).

The presence of phytoplankton blooming causes sunlight to be blocked from penetrating the water column (Taskjelle et al., 2017). This condition causes the photosynthesis process not to run optimally. As a result, the oxygen concentration is reduced (Niu et al., 2021). This can lead to the mass death of aquatic organisms, such as fish, due to a lack of oxygen.

Other consequences can trigger changes in the phytoplankton community structure (Tan & Ransangan, 2017). One type of phytoplankton may become dominant over the other type. If the type of phytoplankton that develops is a dangerous type, such as several types in the Dynophyceae group (Lee et al., 2019), then the waters have decreased in quality. This can have a wider impact, not only on the death of fish and other organisms but also on the level of human health.

Research conducted on the west coast of South Sulawesi, Indonesia by (Tambaru et al., 2021a), and on the south coast of South Sulawesi, Indonesia by (Tambaru, 2022) has reported on the emergence of potentially dangerous phytoplankton species. Similarly, research conducted by (Mujib et al., 2015) in the waters of Makassar, South Sulawesi, Indonesia. However, the abundance of potentially dangerous phytoplankton types is still very low when compared to good quality phytoplankton types.

Anthropogenic activities are one of the factors that cause changes in water quality, especially changes in nutrient concentrations (Wang et al., 2018). Some anthropogenic activities such as agricultural, fishery, industrial, and household activities, produce fertilizer waste, pesticides, feed residues, and detergents, ultimately contributing to an increase in nutrients in the waters.

One of the waters affected by anthropogenic activities is the waters of Kassikebo, Pangkep, South Sulawesi, Indonesia. Of course, the quality of the waters can change. As a result, the abundance of phytoplankton may also change. It can affect the lives of other organisms. To that end, research aimed at analyzing changes in the abundance and structure of phytoplankton communities has been carried out in these waters. This research is the latest research on this water area.

RESEARCH METHODS

Time and Place of Study

The research was conducted from January to July 2022 in the waters around the port of Kassikebo Pangkep, South Sulawesi, Indonesia. Phytoplankton sample identification was carried out at the Marine Microbiology Laboratory of the Department of Marine Sciences, Faculty of Marine and Fisheries Sciences, Hasanuddin University. Based on the preliminary survey, 3 research stations were established. Station I is near the pier, Station II is close to aquaculture, Station III is close to the estuary, and Station IV (Control station) is far from residential areas.

Research Design

This research is a survey research, which is research whose observations are carried out on a number of characteristics (variables) in research subjects directly in the field. In this study, the research design applied was quantitative research.

Phytoplankton Identification

Water sampling for phytoplankton identification is carried out at each station. A total of 100 L of water was filtered using plankton net number 25. A sample of 100 mL of filtered water was put into the sample bottle. Next, preserved with 1% Lugol and then stored in a cool box. Identification of water samples containing phytoplankton is carried out in the laboratory. The phytoplankton sampling time is 10.00 – 14.00 WITA (Tambaru et al., 2021b).

Measurement of Nutrient and Oceanographic Parameters

At each station, 250 mL of water sampling was also carried out to measure nitrate and orthophosphate nutrients in the laboratory. The measurement of oceanographic parameters such as temperature, salinity, pH, and water brightness is carried out directly in the field, along with water sampling for phytoplankton identification.

Data Analysis

Analysis of differences in phytoplankton abundance by the station was analyzed using One Way ANOVA. The relationship of phytoplankton abundance to oceanographic parameters was analyzed with Pearson's Correlation.

RESULTS

There are two classes of phytoplankton found namely Bacillariophyceae and Cyanophyceae. The type of class Bacillariophyceae is the most common when compared to the species of class Cyanophyceae. The proportion of species abundance in both classes can be seen in Figure 1.

Based on the results of phytoplankton identification, 22 species were found scattered at each station. At the station I 15 species were identified, station II detected 13 species, station III recorded 14 species, and station IV had 15 species.

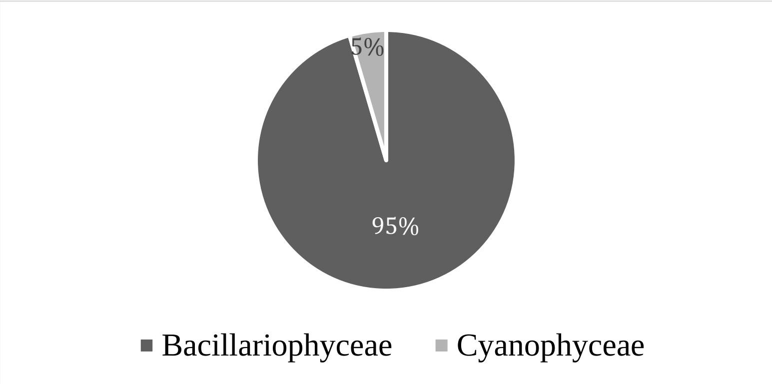

Figure 1. The proportion of Phytoplankton Class

The phytoplankton species found *are Bacteriastrum, Buddilphia, Chaetoceros, Coscinodiscus, Cylindrospermopsis, Cylindrotheca, Detonula, Ditylum, Eucampia, Flagilaria, Guinardia, Halosphaera, Hemiaulus, Isthmia, Leptocylindrus, Nitzschia, Pleurosigma, Proboscia, Rhizosolenia, Skeletonema, Thalassionema*, and *Thalassiosira*. Species that are often found are Skeletonema and Detonula. Both species are members of the Bacillariophyceae group, often found at each station.

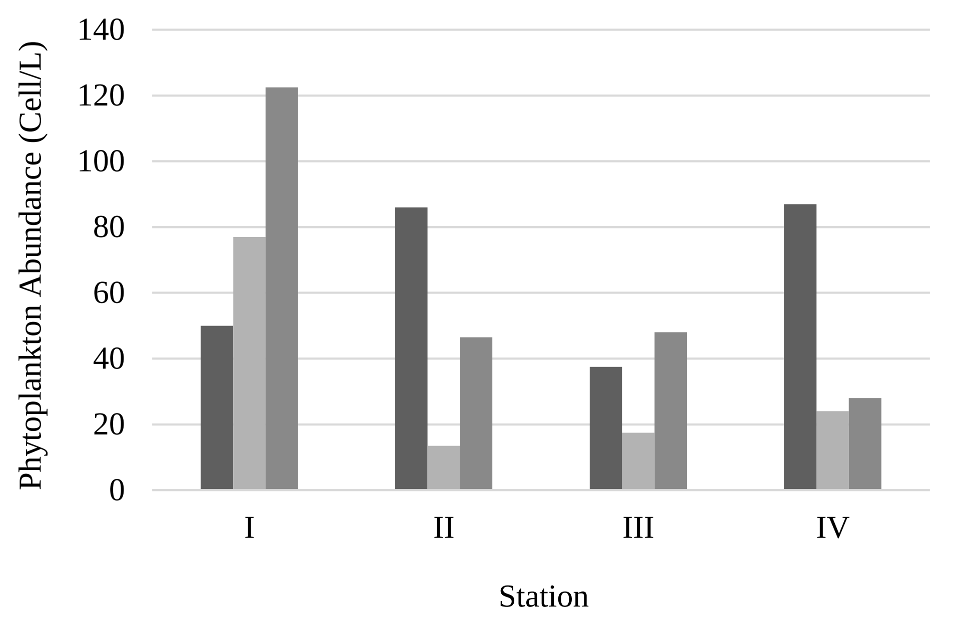

Figure 2. Abundance of Phytoplankton

The phytoplankton abundance at station I has the highest amount of abundance compared to other stations (Table 2 and Figure 2). However, based on One Way ANOVA, phytoplankton abundance is considered the same (no real difference between observation stations, $p>0.05$). Pearson's correlation was used to analyze the relationship of phytoplankton abundance to oceanographic parameters. In this analysis, phytoplankton abundance is the dependent variable, and oceanographic parameters such as temperature, salinity, pH, nitrate, and orthophosphate as independent variables.

Data on the measurement of oceanographic parameters are presented in Table 2. Measured temperature values range from 32°C - 34°C. Salinity ranges from 25 – 29 ppt. The value of the degree of acidity (pH) ranges from 7.15-7.26. Nitrates range from 0.004 – 0.062 mg/L (Table 2), and orthophosphates range from 0.008 – 0.073 mg/L.

Table 2. Results of measurement of oceanographic parameters

Station	Observation repetition	Parameter					
		The abundance of phytoplankton (Cell/L)	Temp (ºC)	Salinity (‰)	pH	Nitrate (mg/L)	Orthophosphate (mg/L)
I	1	50.0	33	25	7.15	0.051	0.019
	2	77.0	32	28	7.20	0.018	0.028
	3	122.5	33	29	7.25	0.038	0.024
II	1	86.0	33	27	7.20	0.015	0.018
	2	13.5	34	27	7.23	0.031	0.010
	3	46.5	33	28	7.23	0.061	0.017
III	1	37.5	33	27	7.20	0.034	0.022
	2	17.5	33	26	7.22	0.062	0.028
	3	48.0	34	27	7.22	0.038	0.073
IV	1	87.0	33	28	7.26	0.004	0.010

2	24.0	32	29	7.26	0.034	0.008
3	280	32	29	7.25	0.026	0.023

The results of Pearson's Correlation analysis showed that phytoplankton abundance only correlated with pH with a negative relationship (r = -0.580, p = 0.045) (Table 3).

Table 3. Results of Pearson correlation analysis

Correlations		
		Abundance of phytoplankton
Abundance of phytoplankton	Pearson Correlation	1
	Sig. (2-tailed)	
	N	12
Temp	Pearson Correlation	-.059
	Sig. (2-tailed)	.857
	N	12
Salinity	Pearson Correlation	-.365
	Sig. (2-tailed)	.243
	N	12
pH	Pearson Correlation	**-.580***
	Sig. (2-tailed)	**.048**
	N	**12**
Nitrate	Pearson Correlation	.091
	Sig. (2-tailed)	.779
	N	12
Orthophosphate	Pearson Correlation	-.031
	Sig. (2-tailed)	.924
	N	12
*. Correlation is significant at the 0.05 level (2-tailed).		
**. Correlation is significant at the 0.01 level (2-tailed).		

DISCUSSION

Bacillariophyceae and Cyanophyceae are the two classes found in this study. Bacillariophyceae has the most species when compared to Cyanophyceae. The same thing was also reported by Tambaru et al. (2018) in Makassar coastal waters and (Tambaru, Samawi, et al., 2021b) in Kuri Maros coastal waters. The high abundance and number of types of class Bacillariophyceae can adapt to changes in environmental conditions widely (Prelle et al., 2019). In low nutrient conditions, they still provide a rapid growth response(Li et al., 2021).

Skeletonema and Detonula are types that are often found at every station. Both types of phytoplankton are groups in the class Bacillariophyceae, often called the diatom group(Scarsini et al., 2019). Diatoms are a common and dominant component of phytoplankton in coastal waters and oceans(Harvey et al., 2019).

The frequency of the two types of phytoplankton is found because of their ability to adapt to diverse environmental conditions, ranging from upstream to river estuaries and seas (Nwe et al., 2021), from the edge to the middle of the ocean (Tibby et al., 2022). Both types are abundant because they can withstand extreme conditions, such as low nutrient concentrations(Spilling et al., 2021). In addition, they have high reproductive power (Ajani et al., 2021), and play an important role as primary producers in waters, this is indicated by their contribution of around 20% of primary production on Earth (Vincent & Bowler, 2020).

Skeletonema is a group of diatoms with cosmopolitan properties. This type is widely distributed in coastal and marine waters. Recent research conducted in the coastal waters of Japan's Ariake has tracked several types of *Skeletonema* that evolved (Yoshida et al., 2023). They found that the occurrence of species in the Skeletonema group had different seasonal patterns. Three species of skeletonema (*S. costatum, S. menzelii, and S. tropicum*) thrive in summer, while others thrive in winter (*S. ardens, S. dohrnii/marinoi, S. grevillei*, and *S. japonicum*). The appearance of the type in the Skeletonema group suggests that they tend to adapt to different environmental conditions. Temperature is an important environmental factor in supporting its development (Canesi & Rynearson, 2016).

Just like Skeletonema, temperature also affects Detonula's life in coastal and marine waters. The process of nutrient absorption is accelerating with an increase in water temperature (Gessay & Smayda, 2016). In addition, the availability of light is another environmental factor that provides support for its development (Laws et al., 2020).

Although phytoplankton abundance was found highest at station I (Table 2 and Figure 2), phytoplankton abundance was considered the same (not significantly different) between observation stations based on variety analysis ($p>0.05$). This may happen because some physical-chemical parameters, for example, the availability of sunlight, are sufficient for phytoplankton needs in activities at all stations. Although not measured in this study, we confirmed that sunlight is widely available in the water column at all stations. This condition affects the speed of phytoplankton growth which is considered the same.

In this study, phytoplankton abundance was detected only correlated with pH with a negative relationship. This correlation can be interpreted, as changes in phytoplankton abundance occurring due to changes in pH values. The abundance of phytoplankton will decrease with the memory of the pH value, and vice versa, up to a certain pH value.

The degree of acidity (pH) influences plant life and aquatic animals. This parameter is often used as a clue to express the good or bad quality of water. For phytoplankton, pH affects the absorption of carbon dioxide in water (Gazeau et al., 2021). Under low pH conditions, the ability of phytoplankton is reduced to absorb carbon dioxide. As a result, the process of photosynthesis does not run perfectly, and the formation of food reserves decreases.

Changes in pH value affect the physiological processes of algae including phytoplankton (Raven et al., 2020). This is a driving factor for the development of several types of harmful phytoplankton (HABs) in the waters. In acidic waters with a pH of less than 6, organisms that feed fish, in this case, phytoplankton, cannot live well.

A study on pH has been reported by (Thoisen et al., 2015). In his observation, the pH value of water in acidic conditions influences decreasing the growth rate of phytoplankton communities. In addition, it exerts an influence on changes in colony size and chain length of selected species. In other studies, the effect of pH on the growth of several types of cyanobacteria and diatoms has also been observed. The results showed that the relative growth became low under acidic pH conditions (Rai & Rajashekhar, 2016).

CONCLUSION

Bacillariophyceae and Cyanophyceae are two classes of phytoplankton found in this study. Bacillariophyceae have more numbers and types when compared to the number and type of class Cyanophyceae. The types that are often found are Skeletonema and Detonula. Both types of phytoplankton are a group of the class Bacillariophyceae. The abundance of phytoplankton at each station was no difference between observation stations. Changes in phytoplankton abundance are due to changes in pH.

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6. RESPONS KE REVIEWER B (Review Kedua)

Response untuk Reviewer B

Jurnal Pendidikan Biologi (JPBIO)

Analysis of Phytoplankton Abundance in Kassikebo Waters, Pangkep Regency, South Sulawesi, Indonesia

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Isi	Komentar Reviewer	Revisi
Data Analysis	Menggunakan apa untuk mengitung korelasi person, jika manual cantumkan rumusnya, jika menggunakan program, apa progam yang digunakan	• Sudah ditambahkan (Hal 3)….. using SPSS 15.0 for Windows
CONCLUSION	Ungkapkan juga, apa implikasi dari penelitian ini	• Sdh ditambahkan (Hal 7): The presence of phytoplankton types as mentioned, shows that the waters around the port of Kassikebo Pangkep, South Sulawesi, Indonesia, are still relatively good.

Analysis of Phytoplankton Abundance in Kassikebo Waters, Pangkep Regency, South Sulawesi, Indonesia

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ABSTRACT

Changes in nutrient concentrations can be caused by anthropogenic activities in coastal and marine waters. This affects the abundance of phytoplankton. The waters experiencing it are the waters of Kassikebo Pangkep, South Sulawesi, Indonesia. For this reason, research has been carried out to analyze the abundance and structure of phytoplankton communities in these waters, from January to July 2022. To identify phytoplankton, 100 L of seawater samples were filtered, which were taken at each station. The results of that water filter, identified in the laboratory. The results showed that the classes of phytoplankton found were Bacillariophyceae and Cyanophyceae. Species found such as Skeletonema and Detonula. The results of One Way ANOVA showed that phytoplankton abundance was not significantly different between observation stations (p>0.05). Changes in phytoplankton abundance are caused by pH.

Citation:

INTRODUCTION

One of the important biotic components in water is phytoplankton (Kamboj et al., 2022; Guo et al., 2019). These microorganisms are microscopic plants (Arundhathy et al., 2021; Manickam et al., 2020), hovering within the water column (Zhang et al., 2021). Its existence is very important in supporting the continuity of the role of aquatic ecosystems in supporting the life of other organisms (Otero et al., 2018), affecting aquatic productivity (Vernet et al., 2019), and determining the fertility level of waters (Tambaru et al., 2021a).

Changes in water quality, such as changes in nutrient concentrations, affect phytoplankton abundance and community structure (Van Meerssche & Pinckney, 2019). Increased nutrient concentrations can lead to increased phytoplankton abundance, leading to blooming in waters. As a result, the surface of the waters can be covered by phytoplankton bodies that experience death (Wang et al., 2018).

The presence of phytoplankton blooming causes sunlight to be blocked from penetrating the water column (Taskjelle et al., 2017). This condition causes the photosynthesis process not to run optimally. As a result, the oxygen concentration is reduced (Niu et al., 2021). This can lead to the mass death of aquatic organisms, such as fish, due to a lack of oxygen.

Other consequences can trigger changes in the phytoplankton community structure (Tan & Ransangan, 2017). One type of phytoplankton may become dominant over the other type. If the type of phytoplankton that develops is a dangerous type, such as several types in the Dynophyceae group (Lee et al., 2019), then the waters have decreased in quality. This can have a wider impact, not only on the death of fish and other organisms but also on the level of human health.

Research conducted on the west coast of South Sulawesi, Indonesia by (Tambaru et al., 2021a), and on the south coast of South Sulawesi, Indonesia by (Tambaru, 2022) has reported on the emergence of potentially dangerous phytoplankton species. Similarly, research conducted by (Mujib et al., 2015) in the waters of Makassar, South Sulawesi, Indonesia. However, the abundance of potentially dangerous phytoplankton types is still very low when compared to good quality phytoplankton types.

Anthropogenic activities are one of the factors that cause changes in water quality, especially changes in nutrient concentrations (Wang et al., 2018). Some anthropogenic activities such as agricultural, fishery, industrial, and household activities, produce fertilizer waste, pesticides, feed residues, and detergents, ultimately contributing to an increase in nutrients in the waters.

One of the waters affected by anthropogenic activities is the waters of Kassikebo, Pangkep, South Sulawesi, Indonesia. Of course, the quality of the waters can change. As a result, the abundance of phytoplankton may also change. It can affect the lives of other organisms. To that end, research aimed at analyzing changes in the abundance and structure of phytoplankton communities has been carried out in these waters. This research is the latest research on this water area.

RESEARCH METHODS

Time and Place of Study

The research was conducted from January to July 2022 in the waters around the port of Kassikebo Pangkep, South Sulawesi, Indonesia. Phytoplankton sample identification was carried out at the Marine Microbiology Laboratory of the Department of Marine Sciences, Faculty of Marine and Fisheries Sciences, Hasanuddin University. Based on the preliminary survey, 3 research stations were established. Station I is near the pier, Station II is close to aquaculture, Station III is close to the estuary, and Station IV (Control station) is far from residential areas.

Research Design

This research is a survey research, which is research whose observations are carried out on a number of characteristics (variables) in research subjects directly in the field. In this study, the research design applied was quantitative research.

Phytoplankton Identification

Water sampling for phytoplankton identification is carried out at each station. A total of 100 L of water was filtered using plankton net number 25. A sample of 100 mL of filtered water was put into the sample bottle. Next, preserved with 1% Lugol and then stored in a cool box. Identification of water samples containing phytoplankton is carried out in the laboratory. The phytoplankton sampling time is 10.00 – 14.00 WITA (Tambaru et al., 2021b).

Measurement of Nutrient and Oceanographic Parameters

At each station, 250 mL of water sampling was also carried out to measure nitrate and orthophosphate nutrients in the laboratory. The measurement of oceanographic parameters such as temperature, salinity, pH, and water brightness is carried out directly in the field, along with water sampling for phytoplankton identification.

Data Analysis

Analysis of differences in phytoplankton abundance by the station was analyzed using One Way ANOVA. The relationship of phytoplankton abundance to oceanographic parameters was analyzed with Pearson's Correlation using SPSS 15.0 for Windows.

RESULTS

There are two classes of phytoplankton found namely Bacillariophyceae and Cyanophyceae. The type of class Bacillariophyceae is the most common when compared to the species of class Cyanophyceae. The proportion of species abundance in both classes can be seen in Figure 1.

Based on the results of phytoplankton identification, 22 species were found scattered at each station. At the station I 15 species were identified, station II detected 13 species, station III recorded 14 species, and station IV had 15 species.

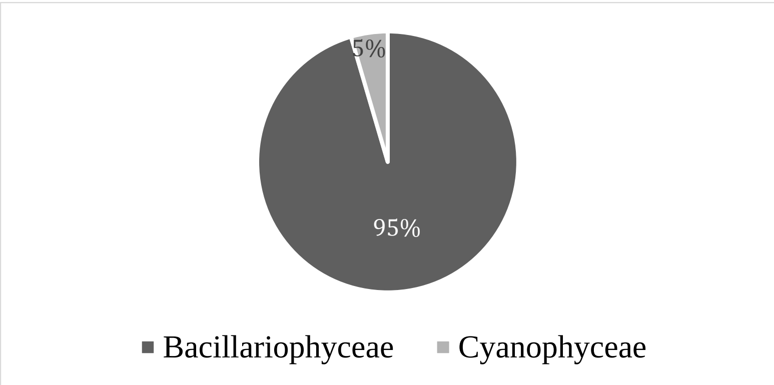

Figure 1. The proportion of Phytoplankton Class

The phytoplankton species found *are Bacteriastrum*, *Buddilphia*, *Chaetoceros*, *Coscinodiscus*, *Cylindrospermopsis*, *Cylindrotheca*, *Detonula*, *Ditylum*, *Eucampia*, *Flagilaria*, *Guinardia*, *Halosphaera*, *Hemiaulus*, *Isthmia*, *Leptocylindrus*, *Nitzschia*, *Pleurosigma*, *Proboscia*, *Rhizosolenia*, *Skeletonema*, *Thalassionema*, and *Thalassiosira*. Species that are often found are Skeletonema and Detonula. Both species are members of the Bacillariophyceae group, often found at each station.

The phytoplankton abundance at station I has the highest amount of abundance compared to other stations (Table 2 and Figure 2). However, based on One Way ANOVA, phytoplankton abundance is considered the same (no real difference between observation stations, $p>0.05$).

Pearson's correlation was used to analyze the relationship of phytoplankton abundance to oceanographic parameters. In this analysis, phytoplankton abundance is the dependent variable, and oceanographic parameters such as temperature, salinity, pH, nitrate, and orthophosphate as independent variables.

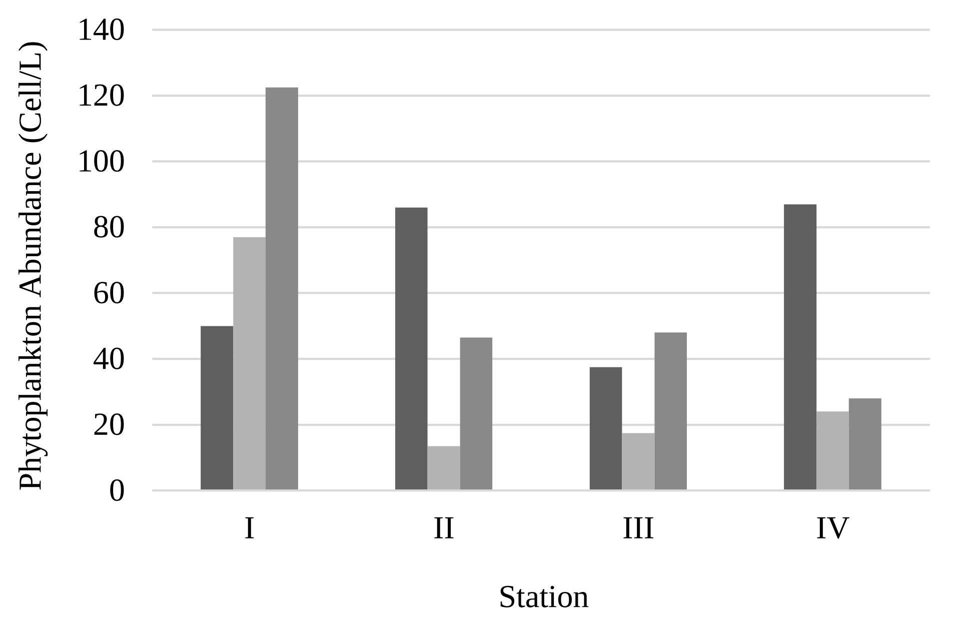

Figure 2. Abundance of Phytoplankton

Data on the measurement of oceanographic parameters are presented in Table 2. Measured temperature values range from 32°C - 34°C. Salinity ranges from 25 – 29 ppt. The value of the degree of acidity (pH) ranges from 7.15-7.26. Nitrates range from 0.004 – 0.062 mg/L (Table 2), and orthophosphates range from 0.008 – 0.073 mg/L.

Table 2. Results of measurement of oceanographic parameters

Station	Observation repetition	Parameter					
		The abundance of phytoplankton (Cell/L)	Temp (ºC)	Salinity (‰)	pH	Nitrate (mg/L)	Orthophosphate (mg/L)
I	1	50.0	33	25	7.15	0.051	0.019
	2	77.0	32	28	7.20	0.018	0.028
	3	122.5	33	29	7.25	0.038	0.024
II	1	86.0	33	27	7.20	0.015	0.018
	2	13.5	34	27	7.23	0.031	0.010
	3	46.5	33	28	7.23	0.061	0.017
III	1	37.5	33	27	7.20	0.034	0.022
	2	17.5	33	26	7.22	0.062	0.028
	3	48.0	34	27	7.22	0.038	0.073
IV	1	87.0	33	28	7.26	0.004	0.010
	2	24.0	32	29	7.26	0.034	0.008
	3	280	32	29	7.25	0.026	0.023

The results of Pearson's Correlation analysis showed that phytoplankton abundance only correlated with pH with a negative relationship ($r = -0.580$, $p = 0.045$) (Table 3).

Table 3. Results of Pearson correlation analysis

Correlations		
		Abundance of phytoplankton
Abundance of phytoplankton	Pearson Correlation	1
	Sig. (2-tailed)	
	N	12
Temp	Pearson Correlation	-.059
	Sig. (2-tailed)	.857
	N	12
Salinity	Pearson Correlation	-.365
	Sig. (2-tailed)	.243
	N	12
pH	Pearson Correlation	**-.580***
	Sig. (2-tailed)	**.048**
	N	**12**
Nitrate	Pearson Correlation	.091
	Sig. (2-tailed)	.779
	N	12
Orthophosphate	Pearson Correlation	-.031
	Sig. (2-tailed)	.924
	N	12
*. Correlation is significant at the 0.05 level (2-tailed).		
**. Correlation is significant at the 0.01 level (2-tailed).		

DISCUSSION

Bacillariophyceae and Cyanophyceae are the two classes found in this study. Bacillariophyceae has the most species when compared to Cyanophyceae. The same thing was also reported by Tambaru et al. (2018) in Makassar coastal waters and (Tambaru, Samawi, et al., 2021b) in Kuri Maros coastal waters. The high abundance and number of types of class Bacillariophyceae can adapt to changes in environmental conditions widely (Prelle et al., 2019). In low nutrient conditions, they still provide a rapid growth response(Li et al., 2021).

Skeletonema and Detonula are types that are often found at every station. Both types of phytoplankton are groups in the class Bacillariophyceae, often called the diatom group(Scarsini et al., 2019). Diatoms are a common and dominant component of phytoplankton in coastal waters and oceans(Harvey et al., 2019).

The frequency of the two types of phytoplankton is found because of their ability to adapt to diverse environmental conditions, ranging from upstream to river estuaries and seas (Nwe et al., 2021), from the edge to the middle of the ocean (Tibby et al., 2022). Both types are

abundant because they can withstand extreme conditions, such as low nutrient concentrations(Spilling et al., 2021). In addition, they have high reproductive power (Ajani et al., 2021), and play an important role as primary producers in waters, this is indicated by their contribution of around 20% of primary production on Earth (Vincent & Bowler, 2020).

Skeletonema is a group of diatoms with cosmopolitan properties. This type is widely distributed in coastal and marine waters. Recent research conducted in the coastal waters of Japan's Ariake has tracked several types of *Skeletonema* that evolved (Yoshida et al., 2023). They found that the occurrence of species in the Skeletonema group had different seasonal patterns. Three species of skeletonema (*S. costatum, S. menzelii, and S. tropicum*) thrive in summer, while others thrive in winter (*S. ardens, S. dohrnii/marinoi, S. grevillei*, and *S. japonicum*). The appearance of the type in the Skeletonema group suggests that they tend to adapt to different environmental conditions. Temperature is an important environmental factor in supporting its development (Canesi & Rynearson, 2016).

Just like Skeletonema, temperature also affects Detonula's life in coastal and marine waters. The process of nutrient absorption is accelerating with an increase in water temperature (Gessay & Smayda, 2016). In addition, the availability of light is another environmental factor that provides support for its development (Laws et al., 2020).

Although phytoplankton abundance was found highest at station I (Table 2 and Figure 2), phytoplankton abundance was considered the same (not significantly different) between observation stations based on variety analysis ($p>0.05$). This may happen because some physical-chemical parameters, for example, the availability of sunlight, are sufficient for phytoplankton needs in activities at all stations. Although not measured in this study, we confirmed that sunlight is widely available in the water column at all stations. This condition affects the speed of phytoplankton growth which is considered the same.

In this study, phytoplankton abundance was detected only correlated with pH with a negative relationship. This correlation can be interpreted, as changes in phytoplankton abundance occurring due to changes in pH values. The abundance of phytoplankton will decrease with the memory of the pH value, and vice versa, up to a certain pH value.

The degree of acidity (pH) influences plant life and aquatic animals. This parameter is often used as a clue to express the good or bad quality of water. For phytoplankton, pH affects the absorption of carbon dioxide in water (Gazeau et al., 2021). Under low pH conditions, the ability of phytoplankton is reduced to absorb carbon dioxide. As a result, the process of photosynthesis does not run perfectly, and the formation of food reserves decreases.

Changes in pH value affect the physiological processes of algae including phytoplankton (Raven et al., 2020). This is a driving factor for the development of several types of harmful phytoplankton (HABs) in the waters. In acidic waters with a pH of less than 6, organisms that feed fish, in this case, phytoplankton, cannot live well.

A study on pH has been reported by (Thoisen et al., 2015). In his observation, the pH value of water in acidic conditions influences decreasing the growth rate of phytoplankton communities. In addition, it exerts an influence on changes in colony size and chain length of selected species. In other studies, the effect of pH on the growth of several types of cyanobacteria and diatoms has also been observed. The results showed that the relative growth became low under acidic pH conditions (Rai & Rajashekhar, 2016).

CONCLUSION

Bacillariophyceae and Cyanophyceae are two classes of phytoplankton found in this study. Bacillariophyceae have more numbers and types when compared to the number and type of class Cyanophyceae. The types that are often found are Skeletonema and Detonula. Both types of phytoplankton are a group of the class Bacillariophyceae. The abundance of

phytoplankton at each station was no difference between observation stations. Changes in phytoplankton abundance are due to changes in pH. The presence of phytoplankton types as mentioned, shows that the waters around the port of Kassikebo Pangkep, South Sulawesi, Indonesia, are still relatively good.

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Analysis of phytoplankton abundance in kassikebo waters, pangkep regency, south sulawesi, indonesia

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ABSTRACT

Changes in nutrient concentrations can be caused by anthropogenic activities in coastal and marine waters. This affects the abundance of phytoplankton. The waters experiencing it are the waters of Kassikebo Pangkep, South Sulawesi, Indonesia. For this reason, research has been carried out to analyze the abundance and structure of phytoplankton communities in these waters, from January to July 2022. To identify phytoplankton, 100 L of seawater samples were filtered, which were taken at each station. The results of that water filter, identified in the laboratory. The results showed that the classes of phytoplankton found were Bacillariophyceae and Cyanophyceae. Species found such as *Skeletonema* and *Detonula*. The results of One-way ANOVA showed that phytoplankton abundance was not significantly different between observation stations ($p>0.05$). Changes in phytoplankton abundance are caused by pH.

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INTRODUCTION

One of the important biotic components in water is phytoplankton (Kamboj et al., 2022; Guo et al., 2019). These microorganisms are microscopic plants (Arundhathy et al., 2021; Manickam et al., 2020), hovering within the water column (Zhang et al., 2021). Its existence is very important in supporting the continuity of the role of aquatic ecosystems in supporting the life of other organisms (Otero et al., 2018), affecting aquatic productivity (Vernet et al., 2019), and determining the fertility level of waters (Tambaru et al., 2021a).

Changes in water quality, such as changes in nutrient concentrations, affect phytoplankton abundance and community structure (Van Meerssche & Pinckney, 2019). Increased nutrient concentrations can lead to increased phytoplankton abundance, leading to blooming in waters. As a result, the surface of the waters can be covered by phytoplankton bodies that experience death (Wang et al., 2018).

The presence of phytoplankton blooming causes sunlight to be blocked from penetrating the water column (Taskjelle et al., 2017). This condition causes the photosynthesis process not to run optimally. As a result, the oxygen concentration is reduced (Niu et al., 2021). This can lead to the mass death of aquatic organisms, such as fish, due to a lack of oxygen.

Other consequences can trigger changes in the phytoplankton community structure (Tan & Ransangan, 2017). One type of phytoplankton may become dominant over the other type. If the type of phytoplankton that develops is a dangerous type, such as several types in the Dynophyceae group (Lee et al., 2019), then the waters have decreased in quality. This can have a wider impact, not only on the death of fish and other organisms but also on the level of human health.

Research conducted on the west coast of South Sulawesi, Indonesia by (Tambaru et al., 2021a), and on the south coast of South Sulawesi, Indonesia by (Tambaru, 2022) has reported on the emergence of potentially dangerous phytoplankton species. Similarly, research conducted by (Mujib et al., 2015) in the waters of Makassar, South Sulawesi, Indonesia. However, the abundance of potentially dangerous phytoplankton types is still very low when compared to good quality phytoplankton types.

Anthropogenic activities are one of the factors that cause changes in water quality, especially changes in nutrient concentrations (Wang et al., 2018). Some anthropogenic activities such as agricultural, fishery, industrial, and household activities, produce fertilizer waste, pesticides, feed residues, and detergents, ultimately contributing to an increase in nutrients in the waters.

One of the waters affected by anthropogenic activities is the waters of Kassikebo, Pangkep, South Sulawesi, Indonesia. Of course, the quality of the waters can change. As a result, the abundance of phytoplankton may also change. It can affect the lives of other organisms. To that end, research aimed at analyzing changes in the abundance and structure of phytoplankton communities has been carried out in these waters. This research is the latest research on this water area.

RESEARCH METHODS

Research Design

This research is a survey research, which is research whose observations are carried out on a number of characteristics (variables) in research subjects directly in the field. In this study, the research design applied was quantitative research.

Time and Place of Study

The research was conducted from January to July 2022 in the waters around the port of Kassikebo Pangkep, South Sulawesi, Indonesia. Phytoplankton sample identification was carried out at the Marine Microbiology Laboratory of the Department of Marine Sciences, Faculty of Marine and Fisheries Sciences, Hasanuddin University. Based on the preliminary survey, 3 research stations were established. Station I is near the pier, Station II is close to aquaculture, Station III is close to the estuary, and Station IV (Control station) is far from residential areas.

Phytoplankton Identification

Water sampling for phytoplankton identification is carried out at each station. A total of 100 L of water was filtered using plankton net number 25. A sample of 100 mL of filtered water was put into the sample bottle. Next, preserved with 1% Lugol and then stored in a cool box. Identification of water samples containing phytoplankton is carried out in the laboratory. The phytoplankton sampling time is 10.00 – 14.00 WITA (Tambaru et al., 2021b).

Measurement of Nutrient and Oceanographic Parameters

At each station, 250 mL of water sampling was also carried out to measure nitrate and orthophosphate nutrients in the laboratory. The measurement of oceanographic parameters such as temperature, salinity, pH, and water brightness is carried out directly in the field, along with water sampling for phytoplankton identification.

Data Analysis

Analysis of differences in phytoplankton abundance by the station was analyzed using One Way ANOVA. The relationship of phytoplankton abundance to oceanographic parameters was analyzed with Pearson's Correlation using SPSS 15.0 for Windows.

RESULTS

There are two classes of phytoplankton found namely Bacillariophyceae and Cyanophyceae. The type of class Bacillariophyceae is the most common when compared to the species of class Cyanophyceae. The proportion of species abundance in both classes can be seen in Figure 1.

Based on the results of phytoplankton identification, 22 species were found scattered at each station. At the station I 15 species were identified, station II detected 13 species, station III recorded 14 species, and station IV had 15 species.

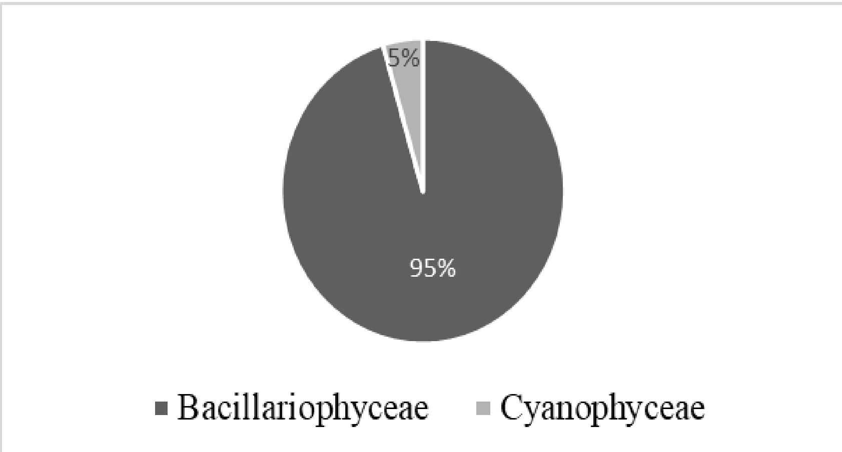

Figure 1. The proportion of Phytoplankton Class

The phytoplankton species found are *Bacteriastrum, Buddilphia, Chaetoceros, Coscinodiscus, Cylindrospermopsis, Cylindrotheca, Detonula, Ditylum, Eucampia, Flagilaria, Guinardia, Halosphaera, Hemiaulus, Isthmia, Leptocylindrus, Nitzschia, Pleurosigma, Proboscia, Rhizosolenia, Skeletonema, Thalassionema*, and *Thalassiosira*. Species that are often found are *Skeletonema* and *Detonula*. Both species are members of the Bacillariophyceae group, often found at each station.

The phytoplankton abundance at station I has the highest amount of abundance compared to other stations (Table 2 and Figure 2). However, based on One Way ANOVA, phytoplankton abundance is considered the same (no real difference between observation stations, $p>0.05$).

Pearson's correlation was used to analyze the relationship of phytoplankton abundance to oceanographic parameters. In this analysis, phytoplankton abundance is the dependent variable, and oceanographic parameters such as temperature, salinity, pH, nitrate, and orthophosphate as independent variables.

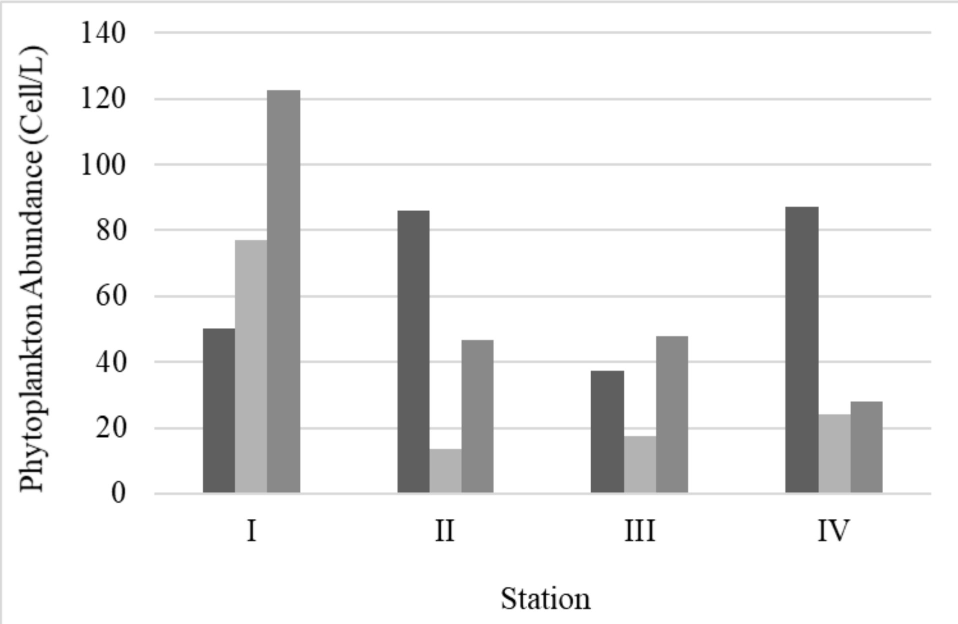

Figure 2. Abundance of Phytoplankton

Data on the measurement of oceanographic parameters are presented in Table 1. Measured temperature values range from 32°C - 34°C. Salinity ranges from 25 – 29 ppt. The value of the degree of acidity (pH) ranges from 7.15-7.26. Nitrates range from 0.004 – 0.062 mg/L (Table 1), and orthophosphates range from 0.008 – 0.073 mg/L.

Table 1. Results of measurement of oceanographic parameters

Station	Observation repetition	Parameter					
		The abundance of phytoplankton (Cell/L)	Temp (°C)	Salinity (‰)	pH	Nitrate (mg/L)	Orthophosphate (mg/L)
I	1	50.0	33	25	7.15	0.051	0.019
	2	77.0	32	28	7.20	0.018	0.028
	3	122.5	33	29	7.25	0.038	0.024
II	1	86.0	33	27	7.20	0.015	0.018
	2	13.5	34	27	7.23	0.031	0.010
	3	46.5	33	28	7.23	0.061	0.017
III	1	37.5	33	27	7.20	0.034	0.022
	2	17.5	33	26	7.22	0.062	0.028
	3	48.0	34	27	7.22	0.038	0.073
IV	1	87.0	33	28	7.26	0.004	0.010
	2	24.0	32	29	7.26	0.034	0.008
	3	280	32	29	7.25	0.026	0.023

The results of Pearson's Correlation analysis showed that phytoplankton abundance only correlated with pH with a negative relationship ($r = -0.580$, $p = 0.045$) (Table 2).

Table 2. Results of Pearson correlation analysis

Correlations		
		Abundance of phytoplankton
Abundance of phytoplankton	Pearson Correlation	1
	Sig. (2-tailed)	
	N	12
Temp	Pearson Correlation	-.059
	Sig. (2-tailed)	.857
	N	12
Salinity	Pearson Correlation	-.365
	Sig. (2-tailed)	.243
	N	12
pH	Pearson Correlation	**-.580***
	Sig. (2-tailed)	**.048**
	N	**12**
Nitrate	Pearson Correlation	.091
	Sig. (2-tailed)	.779
	N	12
Orthophosphate	Pearson Correlation	-.031
	Sig. (2-tailed)	.924
	N	12

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

Bacillariophyceae and Cyanophyceae are the two classes found in this study. Bacillariophyceae has the most species when compared to Cyanophyceae. The same thing was also reported by Tambaru et al. (2018) in Makassar coastal waters and (Tambaru, Samawi, et al., 2021b) in Kuri Maros coastal waters. The high abundance and number of types of class Bacillariophyceae can adapt to changes in environmental conditions widely (Prelle et al., 2019). In low nutrient conditions, they still provide a rapid growth response (Li et al., 2021).

Skeletonema and *Detonula* are types that are often found at every station. Both types of phytoplankton are groups in the class Bacillariophyceae, often called the diatom group (Scarsini et al., 2019). Diatoms are a common and dominant component of phytoplankton in coastal waters and oceans (Harvey et al., 2019).

The frequency of the two types of phytoplankton is found because of their ability to adapt to diverse environmental conditions, ranging from upstream to river estuaries and seas (Nwe et al., 2021), from the edge to the middle of the ocean (Tibby et al., 2022). Both types are abundant because they can withstand extreme conditions, such as low nutrient concentrations (Spilling et al., 2021). In addition, they have high reproductive power (Ajani et al., 2021), and play an important role as primary producers in waters, this is indicated by their contribution of around 20% of primary production on Earth (Vincent & Bowler, 2020).

Skeletonema is a group of diatoms with cosmopolitan properties. This type is widely distributed in coastal and marine waters. Recent research conducted in the coastal waters of Japan's Ariake has tracked several types of *Skeletonema* that evolved (Yoshida et al., 2023). They found that the occurrence of species in the Skeletonema group had different seasonal patterns. Three species of skeletonema (*S. costatum, S. menzelii, and S. tropicum*) thrive in summer, while others thrive in winter (*S. ardens, S. dohrnii/marinoi, S. grevillei*, and *S. japonicum*). The appearance of the type in the Skeletonema group suggests that they tend to adapt to different environmental conditions. Temperature is an important environmental factor in supporting its development (Canesi & Rynearson, 2016).

Just like *Skeletonema*, temperature also affects *Detonula* life in coastal and marine waters. The process of nutrient absorption is accelerating with an increase in water temperature (Gessay & Smayda, 2016). In addition, the availability of light is another environmental factor that provides support for its development (Laws et al., 2020).

Although phytoplankton abundance was found highest at station I (Table 2 and Figure 2), phytoplankton abundance was considered the same (not significantly different) between observation stations based on variety analysis ($p>0.05$). This may happen because some physical-chemical parameters, for example, the availability of sunlight, are sufficient for phytoplankton needs in activities at all stations. Although not measured in this study, we confirmed that sunlight is widely available in the water column at all stations. This condition affects the speed of phytoplankton growth which is considered the same.

In this study, phytoplankton abundance was detected only correlated with pH with a negative relationship. This correlation can be interpreted, as changes in phytoplankton abundance occurring due to changes in pH values. The abundance of phytoplankton will decrease with the memory of the pH value, and vice versa, up to a certain pH value.

The degree of acidity (pH) influences plant life and aquatic animals. This parameter is often used as a clue to express the good or bad quality of water. For phytoplankton, pH affects the absorption of carbon dioxide in water (Gazeau et al., 2021). Under low pH conditions, the ability of phytoplankton is reduced to absorb carbon dioxide. As a result, the process of photosynthesis does not run perfectly, and the formation of food reserves decreases.

Changes in pH value affect the physiological processes of algae including phytoplankton (Raven et al., 2020). This is a driving factor for the development of several types of harmful phytoplankton (HABs) in the waters. In acidic waters with a pH of less than 6, organisms that feed fish, in this case, phytoplankton, cannot live well.

A study on pH has been reported by (Thoisen et al., 2015). In his observation, the pH value of water in acidic conditions influences decreasing the growth rate of phytoplankton communities. In addition, it exerts an influence on changes in colony size and chain length of selected species. In other studies, the effect of pH on the growth of several types of cyanobacteria and diatoms has also been observed. The results showed that the relative growth became low under acidic pH conditions (Rai & Rajashekhar, 2016).

CONCLUSION

Bacillariophyceae and Cyanophyceae are two classes of phytoplankton found in this study. Bacillariophyceae have more numbers and types when compared to the number and type of class Cyanophyceae. The types that are often found are *Skeletonema* and *Detonula*. Both types of phytoplankton are a group of the class Bacillariophyceae. The abundance of phytoplankton at each station was no difference between observation stations. Changes in phytoplankton abundance are due to changes in pH. The presence of phytoplankton types as mentioned, shows that the waters around the port of Kassikebo Pangkep, South Sulawesi, Indonesia, are still relatively good.

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Analysis of phytoplankton abundance in kassikebo waters, pangkep regency, south sulawesi, indonesia

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ABSTRACT

Changes in nutrient concentrations can be caused by anthropogenic activities in coastal and marine waters. This affects the abundance of phytoplankton. The waters experiencing it are the waters of Kassikebo Pangkep, South Sulawesi, Indonesia. For this reason, research has been carried out to analyze the abundance and structure of phytoplankton communities in these waters, from January to July 2022. To identify phytoplankton, 100 L of seawater samples were filtered, which were taken at each station. The results of that water filter, identified in the laboratory. The results showed that the classes of phytoplankton found were Bacillariophyceae and Cyanophyceae. Species found such as Skeletonema and Detonula. The results of One-way ANOVA showed that phytoplankton abundance was not significantly different between observation stations ($p>0.05$). Changes in phytoplankton abundance are caused by pH.

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INTRODUCTION

One of the important biotic components in water is phytoplankton (Kamboj et al., 2022; Guo et al., 2019). These microorganisms are microscopic plants (Arundhathy et al., 2021; Manickam et al., 2020), hovering within the water column (Zhang et al., 2021). Its existence is very important in supporting the continuity of the role of aquatic ecosystems in supporting the life of other organisms (Otero et al., 2018), affecting aquatic productivity (Vernet et al., 2019), and determining the fertility level of waters (Tambaru et al., 2021a).

Changes in water quality, such as changes in nutrient concentrations, affect phytoplankton abundance and community structure (Van Meerssche & Pinckney, 2019). Increased nutrient concentrations can lead to increased phytoplankton abundance, leading to blooming in waters. As a result, the surface of the waters can be covered by phytoplankton bodies that experience death (Wang et al., 2018).

The presence of phytoplankton blooming causes sunlight to be blocked from penetrating the water column (Taskjelle et al., 2017). This condition causes the photosynthesis process not to run optimally. As a result, the oxygen concentration is reduced (Niu et al., 2021). This can lead to the mass death of aquatic organisms, such as fish, due to a lack of oxygen.

Other consequences can trigger changes in the phytoplankton community structure (Tan & Ransangan, 2017). One type of phytoplankton may become dominant over the other type. If the type of phytoplankton that develops is a dangerous type, such as several types in the Dynophyceae group (Lee et al., 2019), then the waters have decreased in quality. This can have a wider impact, not only on the death of fish and other organisms but also on the level of human health.

Research conducted on the west coast of South Sulawesi, Indonesia by (Tambaru et al., 2021a), and on the south coast of South Sulawesi, Indonesia by (Tambaru, 2022) has reported on the emergence of potentially dangerous phytoplankton species. Similarly, research conducted by (Mujib et al., 2015) in the waters of Makassar, South Sulawesi, Indonesia. However, the abundance of potentially dangerous phytoplankton types is still very low when compared to good quality phytoplankton types.

Anthropogenic activities are one of the factors that cause changes in water quality, especially changes in nutrient concentrations (Wang et al., 2018). Some anthropogenic activities such as agricultural, fishery, industrial, and household activities, produce fertilizer waste, pesticides, feed residues, and detergents, ultimately contributing to an increase in nutrients in the waters.

One of the waters affected by anthropogenic activities is the waters of Kassikebo, Pangkep, South Sulawesi, Indonesia. Of course, the quality of the waters can change. As a result, the abundance of phytoplankton may also change. It can affect the lives of other organisms. To that end, research aimed at analyzing changes in the abundance and structure of phytoplankton communities has been carried out in these waters. This research is the latest research on this water area.

RESEARCH METHODS

Research Design

This research is a survey research, which is research whose observations are carried out on a number of characteristics (variables) in research subjects directly in the field. In this study, the research design applied was quantitative research.

Time and Place of Study

The research was conducted from January to July 2022 in the waters around the port of Kassikebo Pangkep, South Sulawesi, Indonesia. Phytoplankton sample identification was carried out at the Marine Microbiology Laboratory of the Department of Marine Sciences, Faculty of Marine and Fisheries Sciences, Hasanuddin University. Based on the preliminary survey, 3 research stations were established. Station I is near the pier, Station II is close to aquaculture, Station III is close to the estuary, and Station IV (Control station) is far from residential areas.

Phytoplankton Identification

Water sampling for phytoplankton identification is carried out at each station. A total of 100 L of water was filtered using plankton net number 25. A sample of 100 mL of filtered water was put into the sample bottle. Next, preserved with 1% Lugol and then stored in a cool box. Identification of water samples containing phytoplankton is carried out in the laboratory. The phytoplankton sampling time is 10.00 – 14.00 WITA (Tambaru et al., 2021b).

Measurement of Nutrient and Oceanographic Parameters

At each station, 250 mL of water sampling was also carried out to measure nitrate and orthophosphate nutrients in the laboratory. The measurement of oceanographic parameters such as temperature, salinity, pH, and water brightness is carried out directly in the field, along with water sampling for phytoplankton identification.

Data Analysis

Analysis of differences in phytoplankton abundance by the station was analyzed using One Way ANOVA. The relationship of phytoplankton abundance to oceanographic parameters was analyzed with Pearson's Correlation using SPSS 15.0 for Windows.

RESULTS

There are two classes of phytoplankton found namely Bacillariophyceae and Cyanophyceae. The type of class Bacillariophyceae is the most common when compared to the species of class Cyanophyceae. The proportion of species abundance in both classes can be seen in Figure 1.

Based on the results of phytoplankton identification, 22 species were found scattered at each station. At the station I 15 species were identified, station II detected 13 species, station III recorded 14 species, and station IV had 15 species.

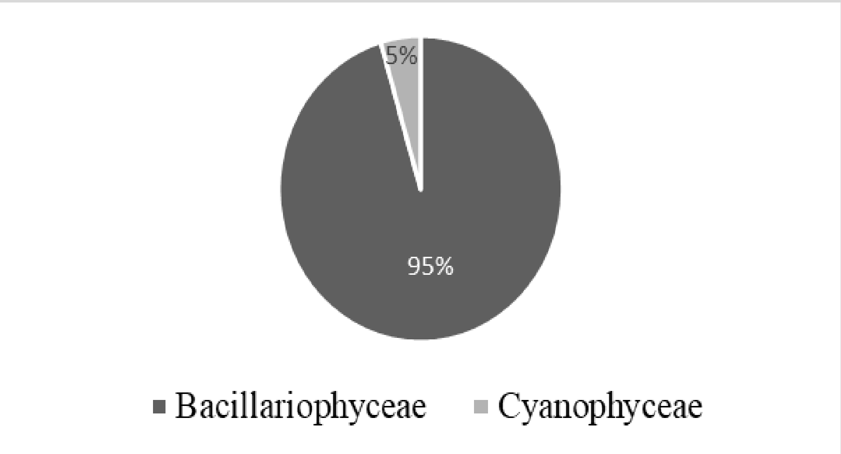

Figure 1. The proportion of Phytoplankton Class

The phytoplankton species found *are Bacteriastrum, Buddilphia, Chaetoceros, Coscinodiscus, Cylindrospermopsis, Cylindrotheca, Detonula, Ditylum, Eucampia, Flagilaria, Guinardia, Halosphaera, Hemiaulus, Isthmia, Leptocylindrus, Nitzschia, Pleurosigma, Proboscia, Rhizosolenia, Skeletonema, Thalassionema*, and *Thalassiosira*. Species that are often found are Skeletonema and Detonula. Both species are members of the Bacillariophyceae group, often found at each station.

The phytoplankton abundance at station I has the highest amount of abundance compared to other stations (Table 2 and Figure 2). However, based on One Way ANOVA, phytoplankton abundance is considered the same (no real difference between observation stations, $p>0.05$).

Pearson's correlation was used to analyze the relationship of phytoplankton abundance to oceanographic parameters. In this analysis, phytoplankton abundance is the dependent variable, and oceanographic parameters such as temperature, salinity, pH, nitrate, and orthophosphate as independent variables.

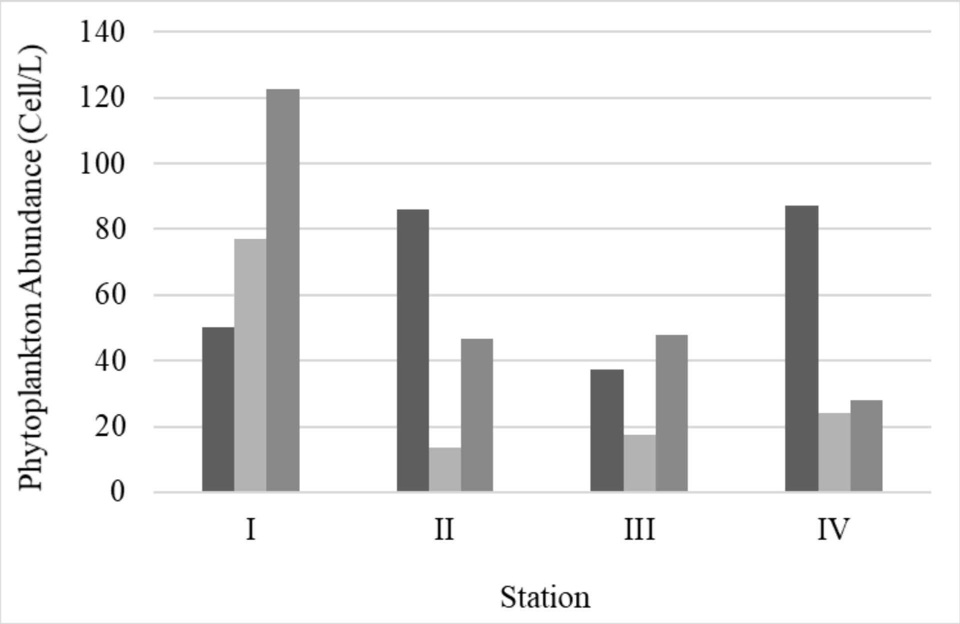

Figure 2. Abundance of Phytoplankton

Data on the measurement of oceanographic parameters are presented in Table 1. Measured temperature values range from 32°C - 34°C. Salinity ranges from 25 – 29 ppt. The value of the degree of acidity (pH) ranges from 7.15-7.26. Nitrates range from 0.004 – 0.062 mg/L (Table 1), and orthophosphates range from 0.008 – 0.073 mg/L.

Table 1. Results of measurement of oceanographic parameters

Station	Observation repetition	Parameter					
		The abundance of phytoplankton (Cell/L)	Temp (°C)	Salinity (‰)	pH	Nitrate (mg/L)	Orthophosphate (mg/L)
I	1	50.0	33	25	7.15	0.051	0.019
	2	77.0	32	28	7.20	0.018	0.028
	3	122.5	33	29	7.25	0.038	0.024
II	1	86.0	33	27	7.20	0.015	0.018
	2	13.5	34	27	7.23	0.031	0.010
	3	46.5	33	28	7.23	0.061	0.017
III	1	37.5	33	27	7.20	0.034	0.022
	2	17.5	33	26	7.22	0.062	0.028
	3	48.0	34	27	7.22	0.038	0.073
IV	1	87.0	33	28	7.26	0.004	0.010
	2	24.0	32	29	7.26	0.034	0.008
	3	280	32	29	7.25	0.026	0.023

The results of Pearson's Correlation analysis showed that phytoplankton abundance only correlated with pH with a negative relationship (r = -0.580, p = 0.045) (Table 2).

Table 2. Results of Pearson correlation analysis

Correlations		
		Abundance of phytoplankton
Abundance of phytoplankton	Pearson Correlation	1
	Sig. (2-tailed)	
	N	12
Temp	Pearson Correlation	-.059
	Sig. (2-tailed)	.857
	N	12
Salinity	Pearson Correlation	-.365
	Sig. (2-tailed)	.243
	N	12
pH	Pearson Correlation	**-.580***
	Sig. (2-tailed)	**.048**
	N	**12**
Nitrate	Pearson Correlation	.091
	Sig. (2-tailed)	.779
	N	12
Orthophosphate	Pearson Correlation	-.031
	Sig. (2-tailed)	.924
	N	12

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

Bacillariophyceae and Cyanophyceae are the two classes found in this study. Bacillariophyceae has the most species when compared to Cyanophyceae. The same thing was also reported by Tambaru et al. (2018) in Makassar coastal waters and (Tambaru, Samawi, et al., 2021b) in Kuri Maros coastal waters. The high abundance and number of types of class Bacillariophyceae can adapt to changes in environmental conditions widely (Prelle et al., 2019). In low nutrient conditions, they still provide a rapid growth response(Li et al., 2021).

Skeletonema and Detonula are types that are often found at every station. Both types of phytoplankton are groups in the class Bacillariophyceae, often called the diatom group(Scarsini et al., 2019). Diatoms are a common and dominant component of phytoplankton in coastal waters and oceans(Harvey et al., 2019).

The frequency of the two types of phytoplankton is found because of their ability to adapt to diverse environmental conditions, ranging from upstream to river estuaries and seas (Nwe et al., 2021), from the edge to the middle of the ocean (Tibby et al., 2022). Both types are abundant because they can withstand extreme conditions, such as low nutrient concentrations(Spilling et al., 2021). In addition, they have high reproductive power (Ajani et al., 2021), and play an important role as primary producers in waters, this is indicated by their contribution of around 20% of primary production on Earth (Vincent & Bowler, 2020).

Skeletonema is a group of diatoms with cosmopolitan properties. This type is widely distributed in coastal and marine waters. Recent research conducted in the coastal waters of Japan's Ariake has tracked several types of *Skeletonema* that evolved (Yoshida et al., 2023). They found that the occurrence of species in the Skeletonema group had different seasonal patterns. Three species of skeletonema (*S. costatum, S. menzelii, and S. tropicum*) thrive in summer, while others thrive in winter (*S. ardens, S. dohrnii/marinoi, S. grevillei*, and *S. japonicum*). The appearance of the type in the Skeletonema group suggests that they tend to adapt to different environmental conditions. Temperature is an important environmental factor in supporting its development (Canesi & Rynearson, 2016).

Just like Skeletonema, temperature also affects Detonula's life in coastal and marine waters. The process of nutrient absorption is accelerating with an increase in water temperature (Gessay & Smayda, 2016). In addition, the availability of light is another environmental factor that provides support for its development (Laws et al., 2020).

Although phytoplankton abundance was found highest at station I (Table 2 and Figure 2), phytoplankton abundance was considered the same (not significantly different) between observation stations based on variety analysis ($p>0.05$). This may happen because some physical-chemical parameters, for example, the availability of sunlight, are sufficient for phytoplankton needs in activities at all stations. Although not measured in this study, we confirmed that sunlight is widely available in the water column at all stations. This condition affects the speed of phytoplankton growth which is considered the same.

In this study, phytoplankton abundance was detected only correlated with pH with a negative relationship. This correlation can be interpreted, as changes in phytoplankton abundance occurring due to changes in pH values. The abundance of phytoplankton will decrease with the memory of the pH value, and vice versa, up to a certain pH value.

The degree of acidity (pH) influences plant life and aquatic animals. This parameter is often used as a clue to express the good or bad quality of water. For phytoplankton, pH affects the absorption of carbon dioxide in water (Gazeau et al., 2021). Under low pH conditions, the ability of phytoplankton is reduced to absorb carbon dioxide. As a result, the process of photosynthesis does not run perfectly, and the formation of food reserves decreases.

Changes in pH value affect the physiological processes of algae including phytoplankton (Raven et al., 2020). This is a driving factor for the development of several types of harmful phytoplankton (HABs) in the waters. In acidic waters with a pH of less than 6, organisms that feed fish, in this case, phytoplankton, cannot live well.

A study on pH has been reported by (Thoisen et al., 2015). In his observation, the pH value of water in acidic conditions influences decreasing the growth rate of phytoplankton communities. In addition, it exerts an influence on changes in colony size and chain length of selected species. In other studies, the effect of pH on the growth of several types of cyanobacteria and diatoms has also been observed. The results showed that the relative growth became low under acidic pH conditions (Rai & Rajashekhar, 2016).

CONCLUSION

Bacillariophyceae and Cyanophyceae are two classes of phytoplankton found in this study. Bacillariophyceae have more numbers and types when compared to the number and type of class Cyanophyceae. The types that are often found are Skeletonema and Detonula. Both types of phytoplankton are a group of the class Bacillariophyceae. The abundance of phytoplankton at each station was no difference between observation stations. Changes in phytoplankton abundance are due to changes in pH. The presence of phytoplankton types as mentioned, shows that the waters around the port of Kassikebo Pangkep, South Sulawesi, Indonesia, are still relatively good.

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