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PHYTOPLANKTON BIODIVERSITY AND POLLUTION BIOINDICATOR IN BOJONEGARA COASTAL WATERS, BANTEN BAY, INDONESIA

Keanekaragaman Fitoplankton dan Bioindikator Pencemaran di Perairan Pesisir Bojonegara, Teluk Banten, Indonesia

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Abstract Coastal waters of Bojonegara in Banten Bay has a lot of pressure from the surrounding environment, including industry and sand mining. The high intensity and limited space encourage reclamation in coastal areas which can trigger changes in water quality. Research was conducted from October to December 2019, aims to analyze the phytoplankton biodiversity and pollution bioindicator of the waters. The phytoplankton was obtained through filtering 50 liters of water at a depth of 30 cm or surface waters. Observations were also made on water quality conditions including transparency, depth, color, temperature, pH, salinity, and dissolved oxygen (in-situ) and turbidity, Total Suspended Solid (TSS), nitrate, nitrite, and total phosphate (ex-situ). Data analysis was performed on abundance, diversity index, eveness and dominance, similarity index, and saprobic index. Based on observations, it is known that the phytoplankton found were in the class Bacillariophyceae, Chlorophyceae, Cyanophyceae, Dinophyceae, and Chrysophyceae. The index values of diversity, eveness, and dominance of phytoplankton each ranged from 0.2223-1.0070; 0,1289-0,5664; and 0.1550-0.8181, respectively. According to these values, the Bojonegara waters were classifeied as mild to moderate ecological pressure. The similar conditions are also indicated by the saprobic index values. The result of Main Component Analysis (PCA) shows the first component with 53.726% variance represented by turbidity parameters, TSS, total phosphate, transparency, depth, temperature, pH, and DO. These parameters have the most influence on the presence of phytoplankton.
Keywords: *Bojonegara, Phytoplankton, Water quality*
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INTRODUCTION

The waters of Banten Bay located in Serang Regency, Banten Province. It have depths ranging from 2-20 meters (Rustam *et al.* 2018). Banten Bay is a lot of pressure from the surrounding environment, including industry and sand mining (Wisha *et al*. 2015). One of the areas that are widely used is Bojonegara district. Bojonegara district has a variety of industrial activities that are growing. The high intensity of industrial activities and limited space encourage reclamation in the coastal area of Bojonegara. It could trigger a change in the quality of the surrounding waters (Liyubayina 2018).

Water quality plays an important role in the life of living things and varies depending on location, time, or weather (Giri and Qiu 2016). Changes in physical and chemical parameters can affect aquatic biota life, one of which is phytoplankton (Desmawati *et al*. 2020). Phytoplankton have a high sensitivity to changes in the aquatic environment (Kowiati *et al*. 2019). The structure of the phytoplankton community is an important parameter in evaluating the water quality. The structure of the community includes composition, abundance, diversity, dominance, and eveness of phytoplankton (Putra *et al*. 2012). Changes in the structure of phytoplankton communities may reflect changing water conditions (Kheireddine *et al*. 2018). One of the common conditions is water pollution.

Water pollution is a decrease in water quality due to the influx of organisms and other components so that the waters do not function according to their designation (Damayanti *et al*. 2018). This can happen in the waters around Bojonegara due to environmental pressures. Therefore, the analysis of phytoplankton community structure and its relation to water quality is very important to determine the status of water pollution around Bojonegara, Banten Bay.

The waters around Bojonegara can be degraded due to industrial waste disposal. This leads to changes in the physical and chemical parameters of the waters. Changes in water quality can impact living organism such as phytoplankton (Jannah and Muchlisin 2012). Abundance, composition and diversity of phytoplankton may change. These changes can directly affect ecosystem function (Gao *et al*. 2018). Therefore, the relationship between phytoplankton and water quality is important to study.

Studies on the relationship of phytoplankton and water quality can be used to determine the status of pollution. The analysis that can be used is saprobic index and saprobic index level. Both analyses used the presence of phytoplankton found to determine the status of the waters (Damayanti *et al*. 2018). In addition, the quality of sediment in heavy metals can also describe the status of pollution in the water. This research was conducted by Wardani et al. (2020) in Banten Bay. The results of the study were metal sources are thought to have an important role in the presence of metals in banten bay. This can affect the status of the waters.

The formulation above can show hypotheses, among others, the structure of phytoplankton communities in the waters around Bojonegara, Banten Bay is influenced by the quality of the waters. It also formulates that the status of its waters is polluted due to changes in water quality. This study aims to analyze the structure of communities (abundance, diversity, eveness, and dominance) of phytoplankton, the relationship of phytoplankton with water quality, and determine the status of water pollution around Bojonegara, Banten Bay.

METHODS

Time and Location

This research was conducted for three months, starting from October to December 2019 with a time interval of one month sampling. Sampling of phytoplankton and water samples was carried out in the Bojonegara coastal waters, Banten Bay (Figure 1). Sampling is done at six stations (Table 1). Phytoplankton analysis was identified in Micro Biology Laboratory I, Department of Aquatic Resources Management. Partial analysis of water quality parameters was conducted in situ and partially analyzed in the Laboratory of Aquaculture Environment, Department of Aquaculture. Both were located in Faculty of Fisheries and Marine Sciences, Bogor Agricultural University.

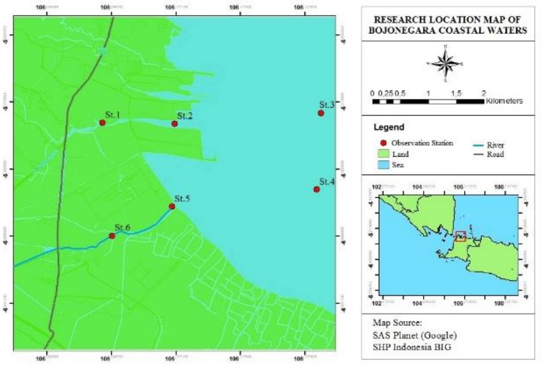


Figure 1 Location map of phytoplankton and water sampling locations in the surrounding waters Bojonegara, Banten Bay

The determination of the station was based on the direction of the water currents and the activities that were around the water. Activities around Bojonegara waters are generally Steampowered Electric Generator (PLTU) and sand mining. Differences in activity at each station can affect the quality of the surrounding waters. The following is the geography position of each station in Bojonegara waters.

Table 1 Geography position of each research station in the waters around Bojonegara

Station	Location Point		Location
	South Latitude (SL)	East Longitude (EL)	
Station 1	05°59.011’	106°05.426’	Padas (settlement and ship deck)
Station 2	05°58.901’	106°06.558’	PT Samudra Marine Indonesia
Station 3	05°58.890’	106°07.713’	Terate (PLTU dan plug chart)
Station 4	05°59.682’	106°07.046’	Terate (PLTU)
Station 5	05°59.773’	106°06.386’	Terate (estuary)
Station 6	06°00.053’	106°05.594’	Terate (river)

Data Collection

Data collection was divided into two, namely primary and secondary data collection. Primary data obtained through observations and measurements in situ as well as the results of analysis in the laboratory. Secondary data obtained from the online data of the Meteorological, Climatological, and Geophysical Agency (BMKG) in the form of rainfall data. This data was used as part of physical factors that can affect the structure of phytoplankton communities. Data was taken for three months at intervals of one month.

In situ water quality observation and measurement of parameters, were transparency, depth, color, temperature, pH, salinity, and dissolved oxygen. Analysis of water quality in the laboratory covered parameters, namely turbidity, Total Suspended Solid (TSS), nitrate, nitrite, and total phosphate. At each sampling station, phytoplankton were obtained through filtering 50 liters of water at a depth of 30 cm or the surface of the water. Sampling phytoplankton using plankton net with a net mesh size of 30 "µ" m. The filtered phytoplankton are then put in polyethylene bottles and lugol iodium preservatives were added to brown for laboratory analysis purposes (APHA 2005).

Water sampling was used Van Dorn water sampler for analysis of some water quality parameters. The sample water that has been taken was then put in a polyethylen sample bottle. Water samples were stored in a coolbox containing ice cubes for laboratory analysis purposes (APHA 2005).

Analysis of Phytoplankton Samples

Calculation of abundance of phytoplankton used a compound microscope binocular Zeiss Primo Star with a magnification of 10x10. Phytoplankton identified will referred several identification books, including Yamaji (1979), Tomas (1997), Conway *et al*. (2003), Suthers and Rissik (2009). Phytoplankton abundance was calculated using the Sedgewick-Rafter Cell (SRC).

$$E = \frac{H'}{\log S}$$

Note:
H' = Shannon Index
S = Species amou nt

Dominance of Phytoplankton

The dominant index used was Simpson's dominant index which has a value range of 0-1. A value approaching 1 indicates low dominance or absence of the dominant type of phytoplankton

(Krebs 1978). The equation used in calculating dominance is as follows (Odum 1996).

$$D = \Sigma\,(ni/N)^2$$

Note:
ni = Individual type amount to-i
N = Individual total amount

Inter-station Similarity Index

Similarity index was used to describe the similarity of phytoplankton communities between stations. The similarity value is between 0 - 100%. A value close to 0% means a low level of similarity and a value close to 100% meaning a level of community similarity between high stations (Odum 1996). The index used was the Bray-Curtis index which has the following equation (Huber 2016).

$$B = 1 - \frac{\sum_{i=1}^{n}\left[X_{ij} - X_{ik}\right]}{\sum\left(X_{ij} + X_{ik}\right)} \times 100\%$$

Note:
B = Similarity index Bray-Curtis
X_{ij} = Individual type amount to-i on the station to-j
X_{ik} = Individual type amount to-i on the station to-k

Multiple Linear Regression Analysis

Multiple linear regression analysis result in a model. Multiple linear regression models of the analysis were then interpreted. The interpretation to ensure that the model is feasible explaining the influence of free variables on bound variables. Therefore, the results of multiple linear regression analysis can describe the relationship between phytoplankton abundance and observed physical and chemical parameters (Ardiansyah *et al*. 2017).

Principal Component Analysis

Analysis of the main components was used in determining the character of each group based on physical, chemical, and biological parameters. This analysis may also explain the relationship between phytoplankton abundance and water quality parameters (Rahman *et al*. 2016). Analysis of the main components until now is widely used and considered important in quantitative ecological analysis (Ismunarti 2013).

Saprobic Index (SI) and Saprobic Index Level (TSI) Analysis

The saprobic index has several phases, namely polystyrene, α-mesosaprobic, β-mesosaprobic, and oligosaprobic. The α-mesosaprobic or β-mesosaprobic phase indicates a change in conditions in an increasingly better direction. Calculation of individuals amount drafting the organic pollution status group in the water using saprobic index level analysis. The equation used to calculate the Saprobic Index (SI) is as follows (Damayanti *et al*. 2018).

$$SI = \frac{1C + 3D + 1B - 3A}{1A + 1B + 1C + 1D}$$

Note:
SI = Saprobic Index
A = Species of organisms polisaprobic amount
B = Species of organisms α–mesosaprobic amount
C = Species of organisms β–mesosaprobic amount
D = Species of organisms oligosaprobic amount

RESULTS AND DISCUSSION

The average abundance of phytoplankton

The abundance of phytoplantons on each month can be different. This is due to changes in the aquatic environment influenced by various factors. Phytoplankton found are five classes, Below was the average abundance of phytoplankton.

Table 2 The average abundance of phytoplankton (ind/L)

ORGANISMS	OCT	NOV	DES
BACILLARIOPHYCEAE			
Asterionellopsis sp.		167,240	
Bacteriastrum sp.	12,750	7,384	4,293
Biddulphia sp.	1,580	1,900	26,760
Chaetoceros sp.	35,530	155,357	754,116
Coscinodiscus sp.	5,840	5,052	9,680
Cyclotella sp.	7,152	112,737	581,136
Diploneis sp.		2,220	
Fragilaria sp.	14,540		
Hemiaulus sp.	1,700	18,633	18,633
Leptocylindrus sp.	9,210		
Melosira sp.	1,800		
Navicula sp.	2,955	3,400	3,030
Nitzschia sp.	3,820	770,408	31,867
Pleurosigma sp.	11,120	2,830	46,453
Rhizosolenia sp.	5,750	28,075	22,950
Terpsinoe sp.	2,160		
Thalassionema sp.	2,510	16,020	
Thalassiosira sp.	116,630	30,680	18,200
Thalassiothrix sp.	86,632	304,273	16,264

Triceratium sp.		1,520	
CHLOROPHYCEAE			
Pediastrum sp.	1,870	7,700	2,800
Scenedesmus sp.		9,900	1,000
CYANOPHYCEAE			
Anabaena sp.		143,292	138,020
Trichodesmium sp.	62,460	158,920	33,000
DINOPHYCEAE			
Ceratium sp.	1,590	27,077	11,530
Dinophysis sp.		9,617	26,590
Peridinium sp.	4,172	35,508	18,820
Prorocentrum sp.		2,467	
Pyrocystis sp.		2,220	9,000
CHRYSOPHYCEAE			
Dictyocha sp.	1,620		
Distephanus sp.		1,520	

Based on the table above can be known the average abundance of phytoplankton. The class at the highest abundance of phytoplankton was Bacillariophyceae. The lowest class of abundance was Chrysophyceae.

Total abundance of phytoplankton

The total abundance of phytoplankton in each month and station is presented in Figure 2. The total abundance of phytoplankton during the study ranged from 73.1 to 8788.98 ind/L. Below was the total abundance of phytoplankton at each station.

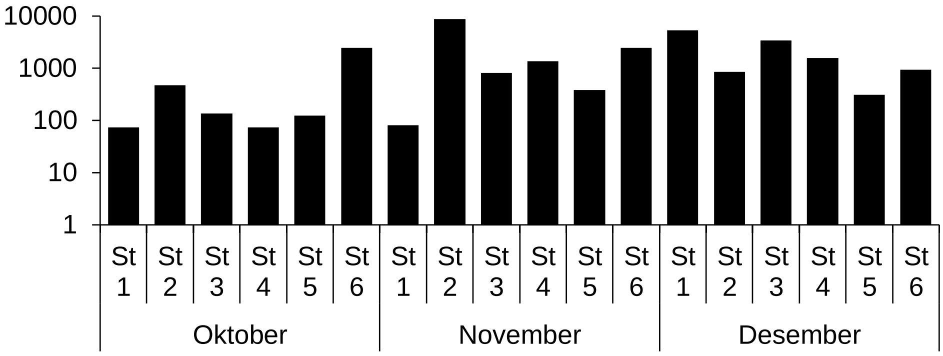
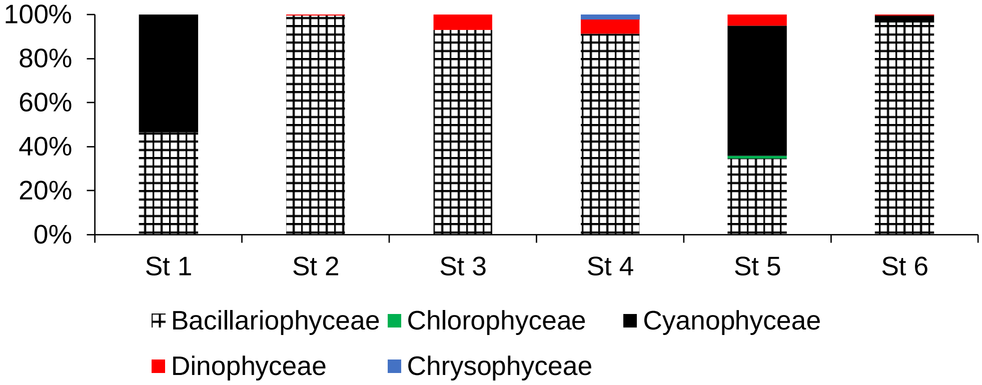


Figure 2 Total abundance of phytoplankton

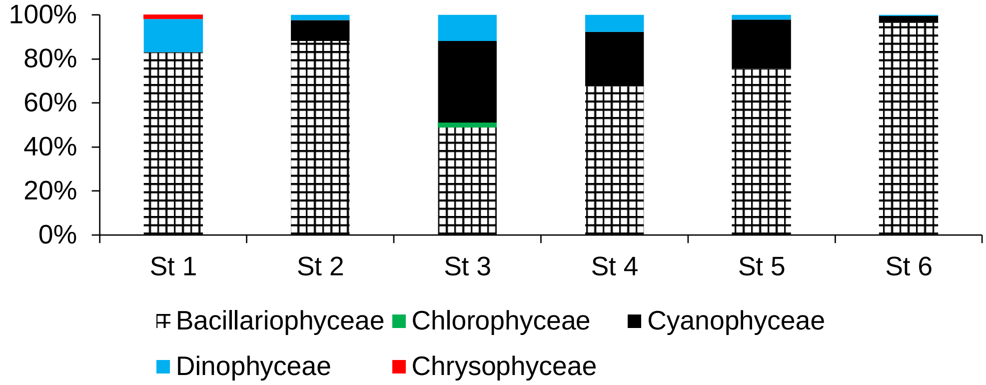
Based on the figure above it is known that station 2 in November has the highest total abundance. Station 1 in October had the lowest total abundance. The figure above shows that the total abundance at each station fluctuates every month.

Composition and abundance of phytoplankton per order per station

The composition of the number of genus and the average abundance of phytoplankton at each station based on class is presented in Figure 3. The composition of the number of phytoplankton species at the station consists of five classes, namely the Bacillariophyceae, Chlorophyceae, Cyanophyceae, Dinophyceae, and Chrysophyceae classes. In the three months, the highest Bacillariophyceae class reached more than 90%



(a)



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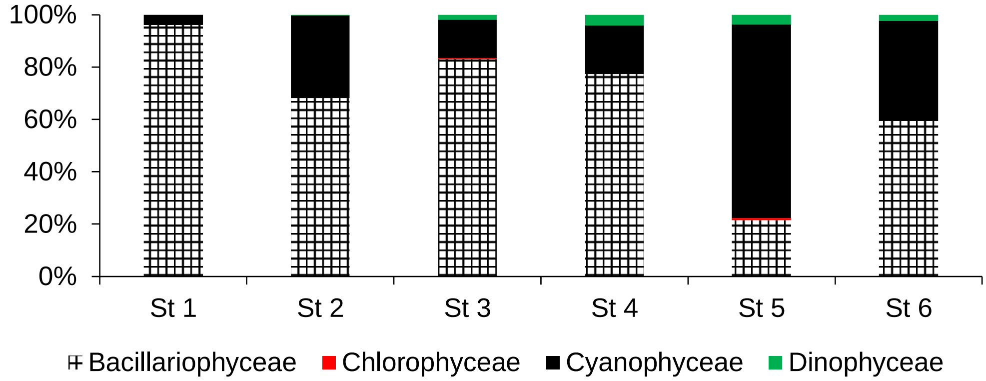
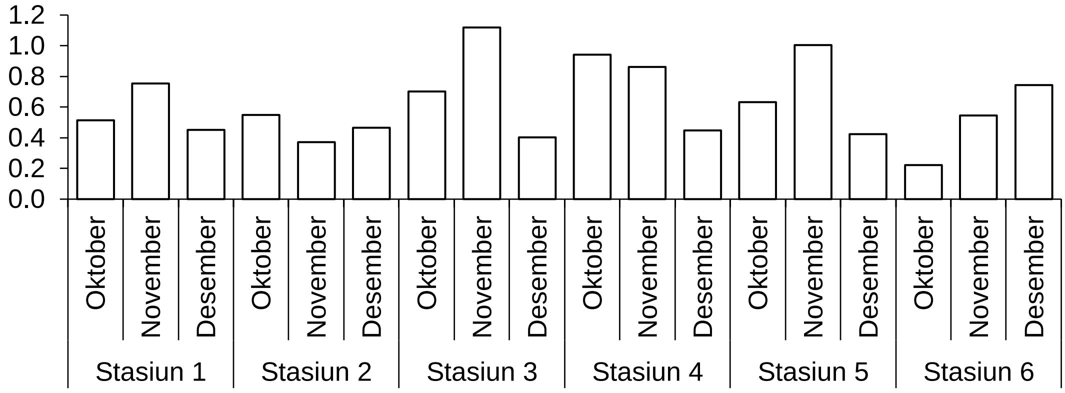


(c)

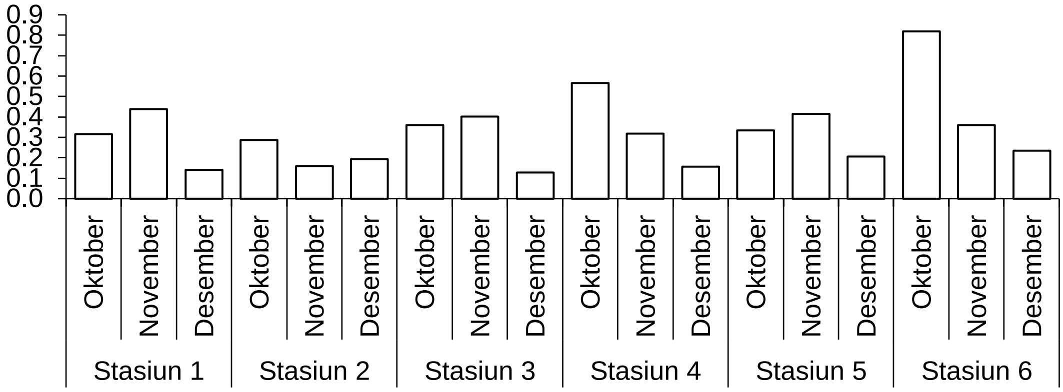
Figure 3 Composition and total abundance of phytoplankton in October (a), November (b), and December (c)

The community structure of the phytoplankton

The diversity, eveness and dominance index can be used to assess the stability of phytoplankton communities in the water. The three index values on phytoplankton are presented in Figure 4. The diversity (Figure 4a), eveness (Figure 4b), and dominance (Figure 4c) of phytoplankton index each range from 0.2223-1.0070; 0.1289-0.5664; and 0.1550-0.8181.



(a)



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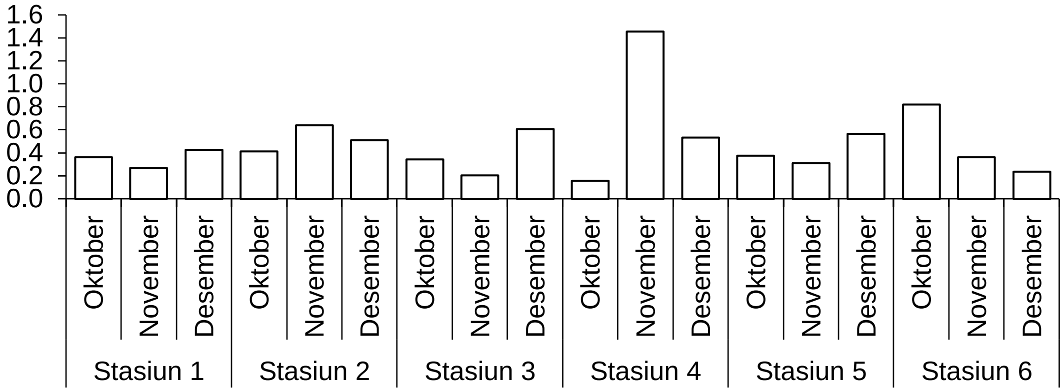

(c)

Figure 4 Diversity (a), eveness (b), and phytoplankton dominance (c) indexes

The highest diversity was at station 3 in November and the lowest was at station 6 in October. The highest eveness were at station 6 in October and the lowest was at station 3 in December. The highest dominance was at station 4 in November and the lowest was at station 4 in October. The results showed that diversity, eveness, and dominance at each station fluctuated. However, in general, the results of this indices indicate that Bojonegara waters are calssified to be low and moderate ecological pressure.

Inter-station similarity index

Grouping stations was based on the results of total abundance of phytoplankton. Grouping used the Euclidean Distance method as an alternative to the Bray-Curtis index method. Illustration of the grouping using dendograms (Figures 5) showing six observation stations into two groups.

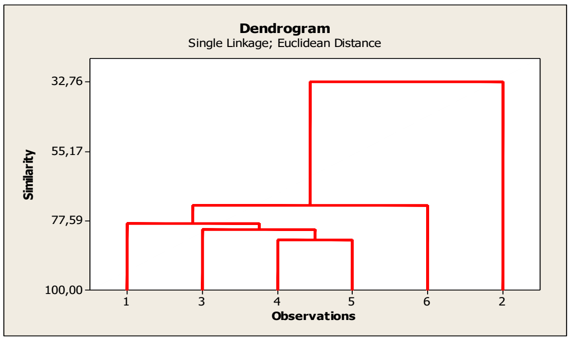

Figure 5 Dendogram grouping stations based on total abundance of phytoplankton

Based on the figure above, it is known that the highest community similarities between stations are stations 4 and 5. This indicates that the two stations have similarities in total abundance of high phytoplankton. The lowest community similarity is station 2. This indicates that this station bears a semblance of the lowest total abundance of phytoplankton.

Primary component analysis

The result of analysis of the main components of one of them is the screen plot. Screen plot is a plot value eigen value to the number of components. The resulting plot to determine the number of components. The results of the screen plot graph show that the components PC1, PC2, and PC3 have a variance (or eigen value) greater than 1. Components less than 1 are ignored. The water quality parameters of Bojonegara waters, Banten Bay are divided into three components, with eigen value and variance as follows.

Table 3 Screen plot table

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	5,910	53,726	53,726
2	2,710	24,638	78,363
3	1,906	17,331	95,694

Component loading is a value that describes the correlation between parameter values formed from the initial data. The sum of squares of each component is the eigen value obtained earlier. This becomes the determinant of the parameters that will be sorted into three components taking into account the position of the component that shows the largest component loading value. Component loading results are seen in the following.

Table 4 *Component loading*

Component Matrix[a]			
	Component		
	1	2	3
Zscore(Turbidity)	**0,821**	0,568	0,039
Zscore(TSS)	**0,715**	0,676	0,030
Zscore(Nitrate)	0,421	-0,038	**0,868**
Zscore(Nitrit)	0,423	**-0,685**	0,560
Zscore(Totalphosphate)	**0,976**	-0,049	-0,061
Zscore(Transparency)	**-0,896**	0,060	0,398
Zscore(Depth)	**-0,753**	0,024	0,582
Zscore(Temperature)	**0,789**	-0,549	-0,257
Zscore(pH)	**-0,851**	-0,455	-0,161
Zscore(Salinity)	-0,257	**0,924**	0,265
Zscore(DO)	**-0,796**	0,304	-0,417
Extraction Method: Principal Component Analysis.			
a. 3 components extracted.			

Based on the table above it can be known that the number that tends to lead to one component has a more significant component loading value. This means that the parameters that go into each component are as follows.

1. The first component with 53.726% variance is represented by turbidity parameters, TSS, total phosphate, transparency, depth, temperature, pH, and DO.
2. The second component with 24.638% variance is represented by nitrite and salinity parameters.
3. The third component with 17.331% variance is represented by nitrate parameters.

Saprobic Index (SI) and Saprobic Index Level (TSI) Analysis

Saprobity levels in the waters can be known through the Saprobic Index (SI) and Saprobic Index Level (TSI). Saprobity levels vary depending on the value obtained. Here's the level of saprobity and the description.

Table 5 Saprobity level

TSI Score	Saprobity level	Description
< -3 s/d -2	Polisaprobic	Heavy pollution
< -2 s/d 0,5	α-Mesosaprobic	Moderate to heavy pollution
0,5 s/d 1,5	β-Mesosaprobic	Mild to moderate pollution
1,5 s/d 2,0	Oligosaprobic	Mild/unpolened pollution

Source: Damayanti *et al.* (2018)

Saprobic phytoplankton Index level in October was 0.6339 and in November was 1.2963. Based on saprobity level table it is known that the saprobity level is β-Mesosaprobic level. This illustrates that the waters around Bojonegara, Banten Bay in October experienced mild to moderate pollution.

Saprobic phytoplankton Index level in December was -0.7102. Based on the saprobity level table it is known that the saprobity level is α-Mesosaprobic level. This illustrates that the waters around Bojonegara, Banten Bay in December experienced moderate to heavy pollution.

Discussion

Euclidean Distance is an alternative that can be used in addition to the Bray-Curtis similarity index. Euclidean Distance depicts the visual influence of the proximity of the quality of the waters around Bojonegara to the abundance of phytoplankton (Idajati and Safitri 2018). Based on euclidean distance analysis it is known that stations 4 and 5 have the highest similar phytoplankton community.

Spatially it is known that in October, stations 4 and 5 have the most similar aquatic conditions. This could corroborate information based on Euclidean Distance's analysis that the two stations share a high phytoplankton community. In November and December, station 2 bears a resemblance to stations 5 and 4. In October, station 2 had similarities in second place.

Based on the results of the analysis above it can be known that the water conditions at stations 2, 4, and 5 have similar characteristics. This happens from October to December. The activities that occurred at the three stations are marine industry, sediment dredging, and Steampowered Electric Generator (PLTU).

According to Mingli et al. (2013), the quality of water in the port area can generally undergo very rapid changes. This is due to the large number of activities, such as cargo handling and ship movement. Nastiti et al. (2012) stated that ship transportation causes water quality to decrease due to oil run-off into the water. Sand mining or sediment dredging can cause an increase in turbidity value so that the transparency value decreases.

According to Rikardo et al. (2016), an abundance of less than 1000 ind/L is categorized as low abundance, 1000-40,000 ind/L belongs to the medium category, and more than 40,000 ind/L fall into the high category. Based on this division it can be known that the abundance of phytoplankton in the waters around Bojonegara is low to moderate. This difference in abundance value can be caused by various factors.

The highest total abundance of phytoplankton was at the 2nd station in November while the lowest was at station 1 in October. The Bacillariophyceae class is the class that has the highest abundance of phytoplankton in the water while the other class is lower. The results of such observations have occurred in various sea waters, one of which is research conducted by Syafarina et al. (2018). Bacillariophyceae is the most common type found compared to others in estuary of Bengawan Solo River, East Java.

This is in accordance with the Sari et al. (2014) is the most common class of Bacillariophyceae found in marine waters. This is because the class has adaptability and a high level of tolerance. This class also has cosmopolitan properties or a wide scope of life.

Five types of phytoplankton in the Bacillariophyceae class that have a high abundance, namely Anabaena sp., Chaetoceros sp., Nitzschia sp., Trichodesmium sp., and Thalassiothrix sp.. One of the important benefits of phytoplankton of the Bacillariophyceae class is that it can be used as an indicator of water pollution (Ejiowhor et al. 2018).

Temperatures are good for the growth of Anabaena sp. between 13.5-28°C (Baliarsingh et al. 2012). Acidity degree for growth is pH more than 6 (Adriansyah et al. 2014). Chaetoceros sp. can grow and develop in sea waters where the temperature is cold to warm (Degerlund et al. (2012). One of the properties of Chaetoceros sp. cosmopolitan (Huseby et al. 2012).

According to Hindarti and Larasati (2019), Nitzschia sp. is a phytoplankton that has the potential as a bioincator because of its wide distribution so that it is easy to find. Nitzschia sp. including the type that is tolerant of pollution (Suwartimah et al. 2011). Trichodesmium sp. is a type of phytoplankton commonly found in marine waters (Gower et al. 2014). The temperature range is good for its life between 19-300C. According to Shahnaz et al. (2018), Thalassiothrix sp. can be used as a pollution bioindicator in the water.

Diversity, eveness, and dominance are essential in the formation of phytoplankton community structures in the waters. The phytoplankton diversity index ranges from 0.2223-1.0070. Here is a table on the criteria for phytoplankton diversity index. Based on the values, it can be known that the diversity of phytoplankton in the waters around Bojonegara is relatively low-moderate level and the spread of individual numbers of each type is also low. This can occur due to water conditions. The phytoplankton eveness index ranges from 0.1289-0.5664. Here is a table on the criteria for phytoplankton eveness index.

Based on the values, it can be known that the eveness of phytoplankton in the waters around Bojonegara is relatively low to high. According to Pagoray and Udayana (2018), this can illustrate that phytoplankton have been able to adapt and compete in utilizing food. Prayan et al. (2014) states that low phytoplankton eveness can indicate waters that have the potential to be dominated certain types of phytoplankton. This can be due to instability of environmental factors and population of microorganisms.

The value of phytoplankton dominance

index ranges from 0.1550-0.8181. According to Pagoray and Udayana (2018), the value of the dominant index close to the value of 1 means that there are certain types that dominate the area of the waters. The Bacillariophyceae class is a phytoplankton that dominates because it is more than 90% of the composition.

Low phytoplankton diversity, followed by low eveness and dominance. This happens from station 1 to station 3. This may indicate that the type of phytoplankton found is few and no type dominates the waters. Yuliana et al. (2012) states that low eveness indicates the spread of each type of individual in an evenly distributed community.

At stations 3 and 5 in November things happen differently. Diversity is high while eveness and dominance are low. According to Pirzan and Pong-Masak (2016), the higher the value of diversity in a water indicates the number of species that can live in these waters. This may indicate that these waters are suitable for phytoplankton life.

At the 4th station in October, diversity and eveness were moderate, while dominance was low. This indicates that no particular species dominates the waters. The spread of each individual type tends to be evenly distributed.

At the 4th station in November, diversity was moderate and eveness was low, while dominance was high. This indicates that there are certain species that dominate the waters. Thalassiothrix sp. is the species that dominates the station. The higher diversity of eveness indicates that the spread of each type of individual is less evenly distributed.

At the 6th station in October, eveness was very high compared to diversity and very low dominance. Phytoplankton diversity can be affected by several things, such as nutrients (abiotic factors) and competition (biotic factors) (Widyarini et al. 2017). The high value of eveness can indicate that eveness between species is evenly distributed (Sari et al. 2014). According to Radiarta dan Erlania (2015), eveness can describe the status of trophic levels in the waters.

Based on multiple linear regression analysis can be known the association of aquatic physical and chemical parameters with phytoplankton. Based on the analysis, it is known that the parameters of temperature, transparency, turbidity, depth, TSS, total phosphate, pH, and DO can already represent the characteristics of the waters around Bojonegara, Banten Bay. The other parameters have no greater influence than the already mentioned parameters.

The correlation of water quality above can be compared with the results of correlation research conducted by Pratiwi et al. (2018) on the same topic. Correlation shows that the parameters that greatly affect phytoplankton are transparency, salinity, DO, and nitrate. The results are both almost the same and may indicate that the parameters tested can already illustrate the influence between water quality and phytoplankton.

The temperature measured in the study ranged from 31.4-41°C. When the water temperature is higher than 30°C although slightly it can cause phytoplankton life to be disrupted. One of the common causes of high temperature measurement results is the time of sampling during the day (Prasetyaningtyas et al. 2012). Such measurable temperatures exceed the temperature range suitable for phytoplankton growth. One of the things that can be affected is the abundance of phytoplankton in the water.

The transparency measured in the study ranged from 19.25-154.5 cm. According to Hasby (2017), low water transparency can cause phytoplankton abundance to be also low. Light penetration may decrease. This is because transparency is important in the process of phytoplankton photosynthesis. One of the things that can be affected is the abundance of phytoplankton in the water.

The turbidity measured in the study ranged from 4.2 to 162 NTU. Turbidity in the waters comes from the content of suspended and dissolved organic and inorganic materials (Wibowo 2014). According to Siagian et al. (2019), the maximum value of turbidity levels in the waters is good for phytoplankton growth of 25 NTU. Turbidity values that exceed the maximum value can affect the abundance of phytoplankton.

The depth measured in the study ranged from 0.36-16.15 m. According to Maresi et al. (2015), the range of depth that can still be penetrated by sunlight well between 0-1.25 m. This is because the layers are productive. The depth of the water is one of the limiting parameters of the fertility of the waters affected by phytoplankton.

TSS measured in the study ranged from 3-123 mg/L. Chapman et al. (2017) states that TSS can affect phytoplankton in movement and increased flocululation. TSS indirectly controls aquatic productivity because it affects the penetration of light into the water and will affect the process of photosynthesis that occurs in phytoplankton (Dwirastina and Wibowo 2015).

Total phosphates measured in the study ranged from 0.001-4.471 mg/L. Total phosphate is one of the nutrients that has the potential as a limiting factor in the growth of phytoplankton, especially diatoms (Drira et al. 2014). According to Verma (2020), phosphates can enter the water through waste disposal ponds or rice fields and decomposed organic matter. One of the things that can be affected is the abundance of phytoplankton in the water.

The degree of acidity or pH measured in the study ranged from 5-7.66. According to Ginting et al. (2015), the pH common to phytoplankton life ranges from 7-8.6. This indicates that bojonegara waters are slightly acidic to neutral. This is less in accordance with the statement of Shahabuddin et al. (2012) that a slightly alkaline pH is suitable for the life of microorganisms. This can affect the abundance of phytoplankton in the water.

Dissolved oxygen measured in the study ranged from 5.3-8.0 mg/L. The minimum DO for phytoplankton survival was 5 mg/L (Ginting et al. 2015). This means that dissolved oxygen in the water is already eligible for phytoplankton life. The value of these parameters can affect the abundance of phytoplankton in the water.

Another factor that can affect the abundance of phytoplankton in a waterway is the seasons. October is part of the transitional season. November and December are included in the rainy season. According to Nirmalasari et al. (2016), when the rainy season generally nutrient levels in the water will be lower than the dry season, so the density of phytoplankton will also be low. This is because the waters in the rainy season have light penetration, salinity, and low temperatures. This condition can increase turbidity levels.

The results of the analysis in October and November β-Mesosaprobic. The waters around Bojonegara, Banten Bay are described as experiencing mild to moderate pollution. The result of the December analysis was α-Mesosaprobic. The pollution that occurs is increasing, namely moderate to severe.

The difference in saprobity value in each month can be influenced by physical and chemical factors of the water. Both factors can affect saprobic organisms directly and indirectly. Levels of mesosaprobic saprobic in the water can be caused by organic and inorganic contaminants (Swary et al. 2014).

Water pollution can occur due to human activities around the water. The activities are Steampowered Electric Generator (PLTU), Fish Market (TPI), community settlement, sediment dredging, and marine industry. This can affect the quality of the surrounding waters even polluted.

Mesosaprobic yields can be associated with an abundance of phytoplankton. Phytoplankton are classified into a small to moderate abundance. Phytoplankton community structures that include diversity, eveness, and dominance indexes show that the waters around Bojonegara are thought to be experiencing instability and show signs of habitat destruction to phytoplankton life. This is due to its low diversity and species dominance in some stations (Rikardo et al. 2016).

CONCLUSION

The results showed that the total abundance of phytoplankton ranged from 73.1-8788.98 ind/L. The index values of diversity, eveness, and dominance of phytoplankton each ranged from 0.2223-1.0070; 0,1289-0,5664; and 0.1550-0.8181. According to these values, the Bojonegara waters were classifeied as mild to moderate ecological pressure. The result of Main Component Analysis (AKU) shows the formation of three component groups, namely the first component with 53.726% variance represented by turbidity parameters, TSS, total phosphate, transparency, depth, temperature, pH, and DO; the second component with 24.638% variance is represented by the parameters nitrite and salinity; and the third component with 17.331% variance is represented by nitrate parameters. Analysis of saprobic index and water saprobic index level ranges from -0.7102 to 1.2963. This indicates the level of water pollution β-Mesosaprobic which is mild to moderate pollution and α-Mesosaprobic is moderate to severe pollution.

DAFTAR PUSTAKA

Adriansyah, Setyawati TR, Lovadi I. 2014. Kualitas perairan kanal Sungai Jawi dan Sungai Raya Dalam Kota Pontianak ditinjau dari struktur komunitas mikroalga perifitik. *Protobiont*. 3(1): 61-70.

[APHA] American Public Health Association. 2005. *Standard Methods For the Examination of Water and Wastewater*. Ed ke-21. Washington DC (US): AWWA (American Water Works Association) and WEF (Water Environment Federation).

Ardiansyah M, Suryanto A, Haeruddin. 2017. Hubungan konsentrasi minyak dan fenol dengan kelimpahan fitophytoplankton di Sungai Asem Binatur, Kota Pekalongan. *Journal of Maquares*. 6(1): 95-102. Asmara YW, Sih A, Nugroho D. 2014. Keragaman dan kelimpahan phytoplankton di Perairan Rawa Pening Ambarawa Kabupaten Semarang. *Jurnal Farmasi*. 3(1): 25-32.

Baliarsingh SK, Sahu BK, Srichandan S, Sahu KC. 2012. Seasonal variation of phytoplankton community in navigable channel of gopalpur port, East Coast of India: a taxonomic study. *International Journal of Modern Botany*. 2(3): 40-46.

Chapman PM, Hayward A, Faithful J. 2017. Total suspended solids effects on freshwater lake biota other than fish. *Bulletin of Environmental Contamination and Toxicology*. 99(4): 423-427.

Conway DV, White RG, Hugues-Dit-Ciles J, Gallienne CP, Robins DB. 2003. *Guide to the Coastal and Surface Zoophytoplankton of the South-Western Indian Ocean*. Plymouth (UK): Occasional Publication of the Marine Biological Association.

Damayanti NPE, Karang IWGA, Faiqoh E. 2018. Tingkat pencemaran berdasarkan saprobitas phytoplankton di perairan Pelabuhan Benoa, Kota Denpasar, Provinsi Bali. *Journal of Marine and Aquatic Sciences*. 4(1): 96-108.

Degerlund M, Huseby S, Zingone A, Sarno D, Landfald B. 2012. Functional diversity in cryptic species of Chaetoceros socialis Lauder (Bacillariophyceae). *Journal of Phytoplankton Research*. 34(5): 416-431.

Desmawati I, Ameivia A, Ardayanti LB. 2020. Studi pendahuluan kelimpahan phytoplankton di perairan darat Surabaya dan Malang. *Rekayasa*. 13(1): 61-66.

Drira Z, Elloumi J, Guermazi W, Hassen MB, Hamza A, Ayadi H. 2014. Seasonal changes on phytoplanktonic diatom communities along an inshore-offshore gradient in the Gulf of Gabes (Tunisia). *Acta Ecologica Sinica*. 34(1): 34-43.

Dwirastina M, Wibowo A. 2015. Karakteristik fisika-kimia dan struktur komunitas phytoplankton perairan Sungai Manna, Bengkulu Selatan. *Limnotek*. 22(1): 76-85.

Ejiowhor I, Moslen M, Daka ER. 2018. Phytoplankton and epipelic algal abundance in relation to bridge construction on Okpoka River in the Upper Bonny Estuary, Nigeria. *Archives of Agriculture and Environmental Science*. 3(4): 337-343.

Gao H, Zhang S, Zhao R, Zhu L. 2018. Phytoplankton community structure analysis and water quality bioassessment in Jiulong Lake. *IOP Conference Series: Earth and Environmental Science*. 199: 1-5.

Ginting IYB, Restu IW, Pebriani DAA. 2015. Kualitas air dan struktur komunitas phytoplankton di perairan Pantai Lovina Kabupaten Buleleng Provinsi Bali. *Journal of Marine and Aquatic Sciences*. 5(1): 109-118.

Giri S, Qiu Z. 2016. Understanding the relationship of land uses and water quality in twenty first century: a review. *Journal of Environmental Management*. 173: 41-48.

Gower J, King S, Young E. 2014. Global remote sensing of *Trichodesmium*. *International Journal of Remote Sensing*. 35(14): 5459-5466.

Hasby M. 2017. Hubungan phytoplankton dan zoophytoplankton terhadap produktivitas kolam agrowisata uir Kecamatan Siak Hulu Kabupaten Kampar Provinsi Riau. *Jurnal Dinamika Pertanian*. 33(3): 251-260.

Hindarti D dan Larasati AW. 2019. Copper (Cu) and cadmium (Cd) toxicity on growth, chlorophyll-a and carotenoid content of phytoplankton *Nitzschia* sp. *IOP Conference Series: Earth and Environmental Science*. 236: 1-9.

Huber S. 2016. Simcadi: similarity indices for categorical distributions. *SSRN Electronic Journal*. 1-11.

Huseby S, Degerlund M, Zingone A. 2012. Metabolic fingerprinting reveals differences between northern and southern strains of the cryptic diatom *Chaetoceros socialis*. *European Journal of Phycology*. 47(4): 480-489.

Idajati H, Safitri EW. 2018. Metode spatial linear regression dalam memprediksi kualitas perairan Danau Ranu Grati Kabupaten Pasuruan. *Jurnal Penataan Ruang*. 13(1): 29-40.

Ismunarti DH. 2013. Analisis komponen utama pada hubungan distribusi spasial komunitas fitophytoplankton dan faktor lingkungan. *Ilmu Kelautan*. 18(1): 14-19.

Jannah R, Muchlisin ZA. 2012. Komunitas fitophytoplankton di daerah estuaria Krueng Aceh, Kota Banda Aceh. *Depik*. 1(3): 189-195.

Kheireddine M, Ouhssain M, Organelli E, Bricaud A, Jones BH. 2018. Light absorption by suspended particles in the red sea: effect of phytoplankton community size structure and pigment composition. *Journal of Geophysical Research: Oceans*. 123(2): 902-921.

Kowiati AI, Sari DR, Amalia RAHT, Sunarti RN, Rohaya R. 2019. Identifikasi keanekaragaman jenis dan jumlah phytoplankton menggunakan *sedwick-rafter* pada sampel air sungai di daerah Sumatera Selatan. *Prosiding Seminar Nasional Sains dan Teknologi*. 2(1): 1-9.

Krebs CJ. 1978. *Ecology: The Experimental Analysis of Distribution and Abundance*. New York (US): Harper & Row.

Liyubayina V. 2018. Analisis dampak reklamasi Teluk Banten terhadap kondisi lingkungan dan sosial ekonomi. *Jurnal Planesa*. 9(1): 37-46.

Maresi SRP, Priyanti P, Yunita E. 2015. Fitophytoplankton sebagai bioindikator saprobitas perairan di Situ Bulakan Kota Tangerang. *AL-Kauniyah: Jurnal Biologi*. 8(2): 113-122.

Mingli Y, Zhang C, Jiang Z, Guo S, Sun J. 2013. Seasonal variations in phytoplankton community structure in the Sanggou, Ailian, and Lidao Bays. *Journal of Ocean University of China*. 13(6): 1012-1024.

Nastiti AS, Sumiono B, Fitriyanto A. 2012. Distribusi spasial dan temporal juvenil udang dalam kaitannya dengan lingkungan perairan di Teluk Jakarta. 18(3): 157-166.

Nirmalasari KP, Lukitasari M, Widianto J. 2016. Pengaruh intensitas musim hujan terhadap kelimpahan fitophytoplankton di Waduk Bening Saradan. *Jurnal Edukasi Matematika dan Sains*. 2(1): 41-47.

Nontji A. 2008. *Phytoplankton Laut*. Jakarta (ID): LIPI Press

Odum EP. 1996. *Dasar-Dasar Ekologi*. *Edisi ketiga*. Yogyakarta (ID): Gadjah Mada University Press.

Pagoray H, Udayana D. 2018. Analisis kualitas phytoplankton dan benthos tambak Bontang Kuala Kota Bontang Kalimantan Timur. *Jurnal Pertanian Terpadu*. 6(1): 30-38.

Pirzan AM, Pong-Masak P. 2016. Hubungan produktivitas tambak dengan keragaman fitophytoplankton di Sulawesi Selatan. 2(2): 211-220.

Prasetyaningtyas T, Priyono B, Pribadi TA. 2012. Keanekaragaman phytoplankton di perairan tambak ikan bandeng di Tapak Tugurejo, Semarang. 1(1): 54-61.

Pratiwi H, Damar A, Sulistiono. 2018. Phytoplankton community structure in the estuary of Donan River, Cilacap, Central Java, Indonesia. *Biodiversitas*. 19(6): 2104-2110.

Prayan Y, Suharto B, Rahadi B. 2014. Analisa kualitas perairan Sungai Klinter Nganjuk berdasarkan parameter biologi (phytoplankton). *Jurnal Sumberdaya Alam dan Lingkungan*. (2): 36-42.

Putra AW, Zahidah, Lili W. 2012. Struktur komunitas phytoplankton di Sungai Citarum Hulu Jawa Barat. *Jurnal Perikanan dan Kelautan*. 3(4): 313-325.

Radiarta IN, Erlania E. 2015. Analisis spasial dan temporal kondisi kualitas perairan melalui pendekatan statistik multivariat di Teluk Gerupuk Provinsi Nusa Tenggara Barat. *Jurnal Riset Akuakultur*. 10(3): 435-447.

Rahman A, Pratiwi NTM, Hariyadi S. 2016. Struktur komunitas fitophytoplankton di Danau Toba, Sumatera Utara. *Jurnal Ilmu Pertanian Indonesia*. 21(2): 120-127.

Rikardo I, Melani WR, Apriadi T. 2016. Keragaman fitophytoplankton sebagai indikator kualitas perairan Muara Sungai Jang Kota Tanjungpinang. *Jurnal Universitas Maritim Raja Ali Haji, Kepulauan Riau*. 1-12.

Rustam A, Adi NS, Mustikasari E, Kepel TL, Kusumaningtyas MA. 2018. Karakteristik sebaran sedimen dan laju sedimentasi perairan Teluk Banten. *Jurnal Segara*. 14(3): 137-144.

Sari AN, Hutabarat S, Soedarsono P. 2014. Struktur komunitas phytoplankton pada padang lamun di Pantai Pulau Panjang, Jepara. *Diponegoro Journal of Maquares*. 3(2): 82-91.

Shahabuddin AM, Oo MT, Yi Y, Thakur DP, Bart AN, Diana JS. 2012. Study about the effect of rice straw mat on water quality parameters, phytoplankton production and mitigation of clay turbidity in earthen fish ponds. *World Journal of Fish and Marine Sciences*. 4(6): 577-585.

Shahnaz L, Naz S, Shehnaz H, Haider A. 2018. Distribution and diversity of phytoplankton from the coastal waters of Manora, Karachi, Pakistan. *International Journal of Biology*. 6(1): 49-57.

Siagian J, Arthana IW, Pebriani DAA. 2019. Tingkat kesuburan Muara Tukad Aya, Jembrana Bali berdasarkan kelimpahan phytoplankton dan ketersediaan nutrien. *Current Trends in Aquatic Science*. 2(2): 72-78.

Suthers IM, Rissik D. 2009. *Phytoplankton: A Guide to Their Ecology and Monitoring for Water Quality*. Clayton (AU): CSIRO Publishing.

Suwartimah K, Widianingsih, Hartati, Wulandari. 2011. Komposisi jenis dan kelimpahan diatom bentik di Muara Sungai Comal Baru Pemalang. *Ilmu Kelautan*. 16(1): 16-23.

Swary A, Hutabarat S, Haeruddin. 2014. Studi pengaruhnya deterjen terhadap komposisi dan kelimpahan fitophytoplankton di Sungai Banjir Kanal Timur Semarang. *Diponegoro Journal of Maquares*. 3(2): 157-165.

Syafarina R, Widodo R, Sulistiono, Pratiwi NTM. 2018. Struktur komunitas fitophytoplankton di perairan muara Sungai Bengawan Solo, Ujung Pangkah, Jawa Timur. *Biospecies*. 11(1): 19-36.

Tomas CR. 1997. *Identifying Marine Phytoplankton*. Florida (US): Academic Press.

Tyas EA, Hutabarat S, Ain C. 2017. Struktur komunitas phytoplankton pada perairan yang ditumbuhi eceng gondok sebagai bioindikator kualitas perairan di Danau Rawa Pening, Semarang. 6(2): 111-119.

Verma AK. 2020. Limnological studies of Muntjibpur pond of Prayagraj (U.P.) in relation to phytoplanktons. *International Journal of Fauna and Biological Studies*. 7(4): 27-30.

Wardani NK, Prartono T, Sulistiono. 2020. Sediments quality based on geo-accumulation index in heavy metals (Pb, Cu, and Cd) of Cengkok coastal waters, Banten Bay. *Jurnal Pendidikan IPA Indonesia*. 9(4): 574-582.

Wibowo M. 2014. Kajian kualitas air dan sedimen dasar Sungai Kutai Lama-Kab. Kutai Kartanegara sebagai pertimbangan awal rencana pengerukan. *Jurnal Presipitasi*. 14(1): 24-29.

Widyarini H, Pratiwi NTM, Sulistiono. 2017. Struktur komunitas zoophytoplankton di muara Sungai Majakerta dan perairan sekitarnya, Kabupaten Indramayu, Provinsi Jawa Barat. *Jurnal Ilmu dan Teknologi Kelautan Tropis*. 9(1): 91-103.

Wisha UJ, Husrin S, Prihantono J. 2015. Hidrodinamika perairan Teluk Banten pada musim peralihan (Agustus–September). *Ilmu Kelautan*. 20(2): 101-112.

Wisha UJ, Yusuf M, Maslukah L. 2016. Sebaran muatan padatan tersuspensi dan kelimpahan fitophytoplankton di muara Sungai Porong Kabupaten Sidoarjo. *Jurnal Kelautan*. 9(2): 122-129.

Yamaji I. 1979. *Illustrations of the Marine Phytoplankton of Japan*. Osaka (JP): Hoikusha.

Yuliana, Adiwilaga EM, Harris E, Pratiwi N. 2012. Hubungan antara kelimpahan fitophytoplankton dengan parameter fisik-kimiawi perairan di Teluk Jakarta. *Jurnal Akuatika*. 3(2): 169-179.