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PHYTOPLANKTON COMMUNITY STRUCTURE IN THE EAST PLAWANGAN OF SEGARA ANAKAN, CILACAP

Struktur Komunitas Fitoplankton di Plawangan Timur Segara Anakan, Cilacap

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ABSTRACT

The East Plawangan waters of Laguna Segara Anakan (LSA), Cilacap are unique waters that are characterized by high biodiversity and are a meeting place for several rivers. It is thought that anthropogenic activities around waters will cause changes in ecological conditions. The organisms that first respond to these changes are phytoplankton. The aim of this research is to determine the structure of the phytoplankton community which includes abundance, diversity index, evenness index and dominance index, as well as to determine physical-chemical factors and the relationship between phytoplankton abundance and physical-chemical factors. The method used is a survey method with Purposive Random Sampling at 5 stations. The f test and Lackey Drop Microtransect Counting method were used to determine the abundance of phytoplankton. Principal Component Analysis (PCA) was used to determine the relationship between phytoplankton abundance and physical-chemical factors. The results showed that the abundance of phytoplankton was in the low and medium categories with values of 840 ± 435 to 3814 ± 939 ind/L; The diversity index ranged from 2.42 - 2.99 (medium); The phytoplankton evenness index ranges between 0.74 - 0.89 (high) and the phytoplankton dominance index ranges from 0.06 - 0.14 (low). Physical-chemical factors in East Plawangan are still at the threshold that can be tolerated by phytoplankton. PCA analysis showed a relationship between phytoplankton abundance and physical-chemical factors as indicated by two main factors (F1 and F2) which produced a variance value of 87.49% with the most influencing factor being orthophosphate.

Keywords: Community Structure, East Plawangan, Phytoplankton, Segara Anakan

ABSTRAK

Perairan Plawangan Timur Laguna Segara Anakan (LSA), Cilacap merupakan perairan unik yang memiliki karakteristik keanekaragaman hayati yang tinggi dan sebagai tempat bertemunya beberapa aliran sungai. Adanya aktivitas antropogenik di sekitar perairan diduga akan menyebabkan perubahan kondisi ekologis. Organisme yang pertama kali merespon adanya perubahan ini adalah fitoplankton. Tujuan penelitian ini adalah untuk mengetahui struktur komunitas fitoplankton yang meliputi kelimpahan, indeks keanekearagaman, indeks kemerataan dan indeks dominansi, serta untuk mengetahui faktor fisik-kimia dan keterkaitan antara kelimpahan fitoplankton dengan faktor fisik-kimia. Metode yang digunakan yaitu metode survey dengan Purposive Random Sampling di 5 stasiun. Uji f dan metode Lackey Drop Microtransect Counting digunakan untuk mengetahui kelimpahan fitoplankton. Principal Component Analysis (PCA) digunakan untuk mengetahui keterkaitan antara kelimpahan fitoplankton dengan faktor fisik-kimia. Hasil penelitian menunjukkan kelimpahan fitoplankton dalam kategori rendah dan sedang dengan nilai 840 ± 435 sampai 3814 ± 939 ind/L; Indeks keanekaragaman berkisar antara 2,42 - 2,99 (sedang); Indeks kemerataan fitoplankton berkisar antara 0,74 - 0,89 (tinggi) dan Indeks dominansi fitoplankton berkisar antara 0,06 - 0,14 (rendah). Faktor fisik-kimia di Plawangan Timur masih berada pada ambang batas yang dapat ditoleransi oleh fitoplankton. Analisis PCA menunjukkan keterkaitan antara kelimpahan fitoplankton dengan faktor fisik-kimia yang ditunjukkan oleh dua faktor utama (F1 dan F2) yang menghasilkan nilai ragam 87,49 % dengan faktor yang paling mempengaruhi yaitu orthophosfat.

Kata Kunci: Fitoplankton, Plawangan Timur, Struktur Komunitas, Segara Anakan

INTRODUCTION

Segara Anakan Lagoon (LSA) is an estuarine water area where several large rivers meet, such as the Kembang Kuning River, Sapuregel River and Donan River. Segara Anakan Lagoon is located in the waters of the South Coast of Java Island at coordinates 7043'17"–7045'19"S and 108056'58"–109002'12"E (Dewi *et al*., 2016). The LSA is connected by two canals (Plawangan), namely East Plawangan which is in the eastern part of Nusakambangan Island and West Plawangan (Ardli & Wolff, 2009). The East Plawangan area is the center of anthropogenic activities, such as the petroleum processing industry, cement, transportation, settlements and other domestic activities. It is feared that this activity could result in degradation of water quality and affect the composition of aquatic biota (Piranti et al., 2018). River flows originating from the Kembang Kuning River, Sapuregel River and Donan River have an influence on fresh water supplies in the eastern part of LSA. These three river flows carry sediment material and macronutrients into the eastern LSA (Dewi *et al*., 2020), which will influence the abundance of phytoplankton.

Phytoplankton are microscopic aquatic organisms that live in the water and are autotrophic or can produce their own food. Usually phytoplankton are often referred to as vegetable plankton (Arifin &Arisandi, 2020). Phytoplankton has a distinctive characteristic, namely that it has chlorophyll which is used to carry out the photosynthesis process (Meiriyani *et al*., 2011). Phytoplankton is an important component in waters because it functions as primary producers in the food chain. As primary producers, phytoplankton have the ability to produce energy by converting nutrients and solar energy into carbohydrates (Mulyadi *et al*., 2019). Based on differences in photosynthetic pigments, phytoplankton are grouped into 5 divisions, namely Cyanophyta, Chrysophyta, Pyrrophyta, Chlorophyta and Euglenophyta (Philip, 1993).

Phytoplankton can be used as a bioindicator of water quality because it has a fast response to changes in the surrounding environment. Phytoplankton populations often experience changes in species composition and quantity due to changes in water quality, especially nutrients which can influence phytoplankton composition (Nugroho, 2006). Temperature, salinity, light and nutrient availability are important factors for the distribution of phytoplankton (Juadi *et al*., 2018).

Phytoplankton community structure is a collection of phytoplankton organisms that exist in a particular environment, which is influenced by environmental conditions and limiting factors (Odum, 1998). A community has a certain structure and pattern of diversity, abundance, evenness and dominance (Husamah *et al*., 2016). The dynamics of abundance and structure of phytoplankton communities are influenced by environmental conditions, especially physical, chemical factors and nutrient availability (Lathifah *et al*., 2017).

One of the problems that occurs in East Plawangan waters is changes in environmental conditions caused by increasing anthropogenic activities around the waters. Each river has different environmental conditions. The existence of phytoplankton organisms in waters is influenced by physical and chemical factors of the water. Therefore, a study of the structure of the phytoplankton community in East Plawangan Segara Anakan, Cilacap was carried out to show that variations in environmental conditions can influence the composition and abundance of phytoplankton.

METHODS

Research Sites

This research was conducted on the moon July 2020, in East Plawangan Segara Anakan, Cilacap, Central Java. In situ parameter observations include temperature, brightness, pH, Biological Oxygen Demand (BOD) and salinity. Ex situ parameter observations including nitrate and orthophosphate were carried out at the Wahana Laboratory, Semarang, turbidity and BOD were carried out at the Laboratory of the Faculty of Fisheries and Marine Sciences, Jendral Soedirman University.

Sampling

The method used in this research is the survey method. The sampling technique was purposive random sampling. The sampling locations are divided into 5 (five) predetermined stations (Figure 1; Table 1). Each sample station was taken with three repetitions. Each repetition of the sample is taken by filtering 150 L of sample water.

Research Parameters

Parameters carried out include; number of species, number of individuals of each phytoplankton species and physical-chemical parameters including temperature, brightness, salinity, turbidity, pH, BOD, nitrate and orthophosphate.

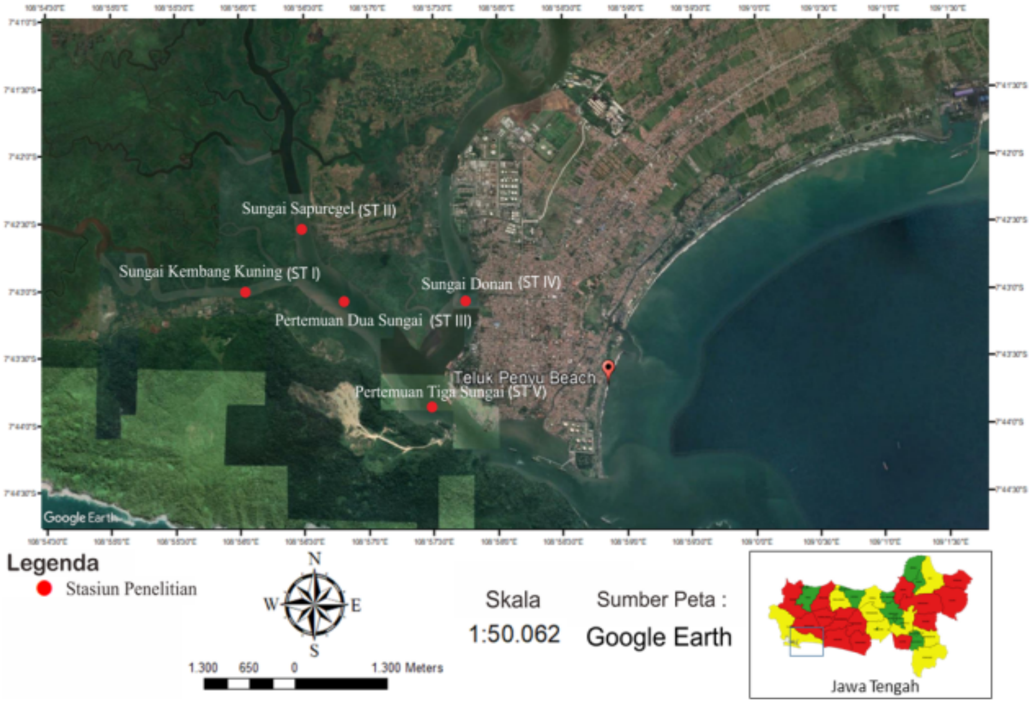

Figure 1. Sampling Locations and Stations

Table 1. Sampling Location

Station	Location	Coordinate
I	Estuary of the Kembang Kuning River	108º96'02" (BT)- 7º70'04" (LS)
II	Sapuregel River Estuary	108º95'06" (BT)- 7º71'06" (LS)
III	The confluence of the Sapuregel and Kembang Kuning River Estuaries	108º96'05" (BT)- 7º71'05" (LS)
IV	Donan Estuary	108º99'01" (BT)- 7º72'03" (LS)
	The confluence of the Sapuregel, Kembang Kuning and Donan River Estuaries	108º98'05" (BT)- 7º73'05" (LS)

Collection and Preservation of Phytoplankton Samples

Water samples were taken at a water depth of 0.5 – 1 m with 150 L of water (APHA, 2005). Samples were filtered using plankton net no. 25 with a mesh size of 60 mm. The water samples were collected in a net plankton container bottle and transferred into a 30 ml sample bottle. Preservation is carried out by adding 40% formalin solution to 4% with the dilution formula, and 2 drops of Lugol's solution, then labeling (Adriana *et al*., 2017). Then the sample was cooled in an ice box and observed.

Phytoplankton Identification

After the phytoplankton sample was obtained, the sample water in the sample bottle was observed using a microscope with a magnification of 10x10 for 30 fields of view. The sample was homogenized until evenly distributed and 1 drop of sample water was taken using a pipette. Each sample was repeated 3 times (Arifin & Arisandi, 2020). Phytoplankton were identified using plankton identification books (Yamaji, 1984), Sachlan (1982), Van Vuuren *et al*. (2006) and Bellinger & Sigee (2010).

Data Collection

Abundance

The formula for calculating phytoplankton abundance using Lackey Drop Microtransect Counting (APHA, 1989) is:

$$N = n \times \frac{A}{B} \times \frac{C}{D} \times \frac{1}{E}$$

Information:
N = Total number of plankton
A = Area of the cover glass (18 x 18 mm^2)
B = Area of one field of view (1, 11279 mm^2)
C = Volume of filtered water (30 mL)
D = Volume of one drop of water (0.05 mL) under the cover glass
E = Volume of filtered water (150 L)
n = Total average number of individuals per field of view

Diversity Index

The Diversity Index indicates the number of types of organisms in an area. The Shannon-Wiener diversity index formula according to Odum (1994) is:

$$H' = -\sum Pi \ln Pi$$

Information:
H' = Shannon-Wiener diversity index
Pi = ni/N
ni = Number of species of type 1
N = Total number of species

Evenness Index

Evenness is the composition of individuals of each species found in a community. The evenness index formula according to Odum (1994) is:

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

Information:
E = Evenness index
H' = Diversity index
H max = ln S (S is the number of species)

Dominance Index

The dominance index formula according to Barus (2004) is as follows:

$$D = \sum_{i=1}^{n} \left[\frac{Ni}{N}\right]^2$$

Information:
D = Dominance index
Ni = Number of individuals of each type
N = Total number of individuals

Measurement of Physical-Chemical Parameters

Water quality sampling is carried out in two ways, namely water samples measured in situ including temperature, brightness and salinity. Ex situ which includes BOD, turbidity, pH, nitrate and orthophosphate. This measurement includes water quality parameters, units and measurement methods.

Table 2. Measurement of Physical-Chemical Parameters

No	Parameter	Unit	Method	Source
1	Temperature	°C	Expansion	APHA (2017)
2	Brightness	cm	*Secchi disk*	APHA (2017)
3	Salinity	ppt	Conductivitimetry	APHA (2017)
4	Turbidity	NTU	Turbidimetry	APHA (2017)
5	Ph	Units	Electrometry	APHA (2017)
6	BOD	mg/L	Winkler	APHA (2017)
7	Nitrate	mg/L	Spectrophotometry	APHA (2017)
8	Orthophosphate	mg/L	Spectrophotometry	APHA (2017)

Data Analysis

The data obtained is presented in tabular form. Next, the phytoplankton abundance data between stations was analyzed using the F test. Data on the diversity index, evenness index and phytoplankton dominance index were analyzed using comparative descriptives. According to Ulber (2009), comparative descriptive is comparing the same variables for different samples.

Analysis of the relationship between phytoplankton abundance and physical parameters-chemistry using the Principle Component Analysis (PCA) method. PCA is a multivariate analysis method used to reduce the dimensions of the original variables so that new variables are obtained that are not correlated but retain most of the information contained in the original variables which produces an output in the form of a matrix (Yordani *et al.,* 2011).

RESULT

Phytoplankton Community Structure

Phytoplankton Abundance

The results of this research found 50 types of phytoplankton with a total abundance of 9352 ± 3155 ind/L. The phytoplankton found includes 5 divisions, namely Chrysophyta, Cyanophyta, Chlorophyta, Pyrrophyta, and Euglenophyta. The abundance of phytoplankton in East Plawangan, Segara Anakan, is presented in Table 3.

Table 3. Abundance of Phytoplankon in East Plawangan Segara Anakan, Cilacap

Division	Phytoplankton Abundance (ind/l)				
	Station I	Station II	Station III	Station IV	Station V
Chrysophyta	3610 ± 782	2197 ± 656	1031 ± 427	589 ± 261	833 ± 243
Cyanophyta	78 ± 53	0 ± 0	0 ± 0	13 ± 13	0 ± 0
Chlorophyta	91 ± 73	351 ± 285	100 ± 77	234 ± 161	134 ± 48
Pyrrophyta	26 ± 23	43 ± 30	9 ± 15	4 ± 8	0 ± 0
Euglenophyta	9 ± 8	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Total	3814 ± 939	2591 ± 971	1140 ± 519	840 ± 435	967 ± 291

Diversity Index

Based on the results of the analysis carried out in East Plawangan Segara Anakan, Cilacap, 50 types of phytoplankton species were found, including 26 types of Chrysophyta species, 4 types of Cyanophyta species, 16 species of Chlorophyta, 3 types of Pyrrophyta species and 1 type of Euglenophyta. The phytoplankton diversity index in East Plawangan Segara Anakan Cilacap is presented in Figure 2.

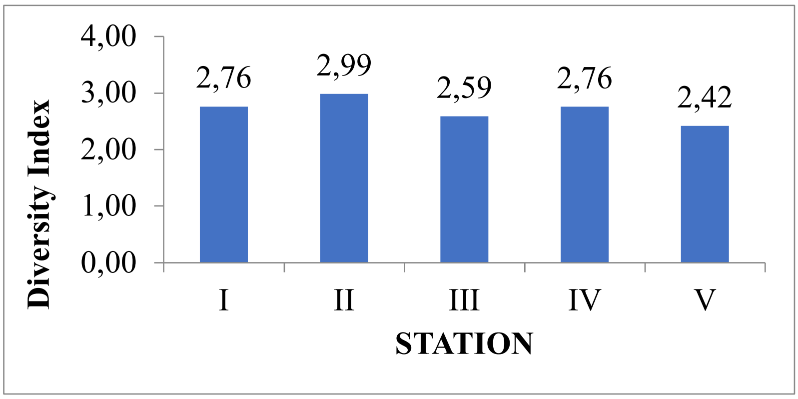

Figure 2. Phytoplankton Diversity Index Found in Segara Anakan Lagoon, Cilacap

Evenness Index

The evenness of phytoplankton shows the composition of each individual species found in a community. The phytoplankton evenness index is presented in Figure 3.

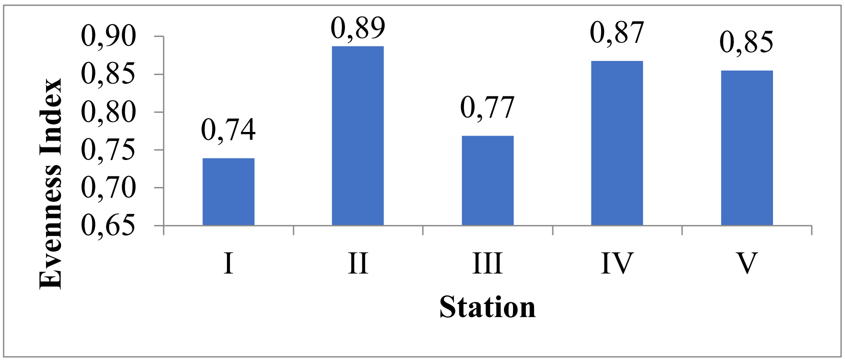

Figure 3. Phytoplankton Evenness Index found in the Segara Anakan Lagoon, Cilacap

Dominance Index

Phytoplankton dominance shows whether or not biota dominates the community. The phytoplankton dominance index in East Plawangan Segara Anakan, Cilacap is presented in (Figure 4).

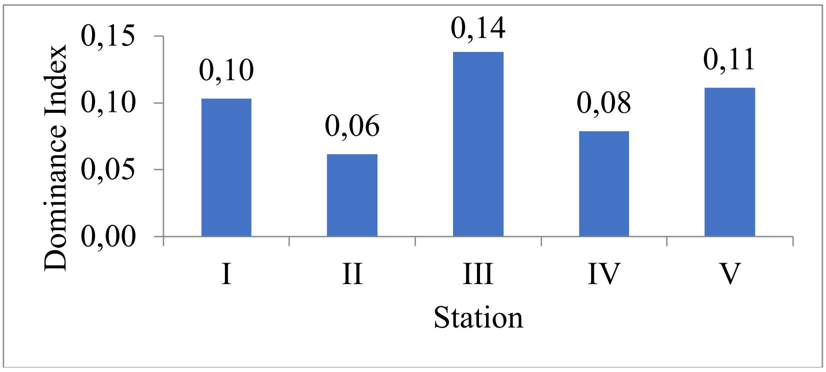

Figure 4. Phytoplankton Dominance Index found in the Segara Anakan Lagoon, Cilacap

Physical-Chemical Parameters

The results of the analysis of physical-chemical parameters in East Plawangan Segara Anakan Cilacap are presented in Table 4. Physical-chemical parameter measurements carried out included temperature, brightness salinity, turbidity pH, BOD, nitrate and orthophosphate.

Table 4. Physical-chemical parameters in East Plawangan Segara Anakan, Cilacap

Parameter	Unit	Range					Quality Standards
		Station I	Station II	Station III	Station IV	Station V	
Temperature	◦C	27-28	28-29	28-29	29-31	28	28-32
Salinity	ppt	15	17-18	20-21	26-27	26-28	33-34
Brightness	cm	64-67	40-47	60-70	64-84	73-82	≥300
pH	Units	7.5-7.6	7.4-7.5	7.6-7.8	7.8-7.9	7.7-7.8	7-8.5
Turbidity	NTU	8.3-20.8	42.7-45.6	18.4-32.9	10,6-14,8	10,7-27,9	<5
BOD	mg/L	3,07-4.4	3,9-5,4	5,7-6,4	9,6-10,4	7,6-9,2	<20
Nitrat	mg/L	4,08-7,13	6,09-7,38	4,82-7,92	4,17-6,99	5-7,21	<0,06
Ortophosfat	mg/L	0,088-0,120	0,073-0,118	0,092-0,114	0,08-0,118	0,097-0,123	<0.015

The Relationship Between Phytoplankton Abundance and Physical-Chemical Factors

The relationship between physical-chemical factors from the results of PCA analysis shows that the relationship between parameters and stations is dominated by two main factors, namely F1 and F2, which produce the largest variance value, namely 87.49%. This shows that the principal component analysis of these two factors can explain the data up to 87.49%. Most of the information is contained in F1, this axis explains 62.88% of the total variance, while F2 explains 24.61% of the total variance. This is presented in (Figure 5).

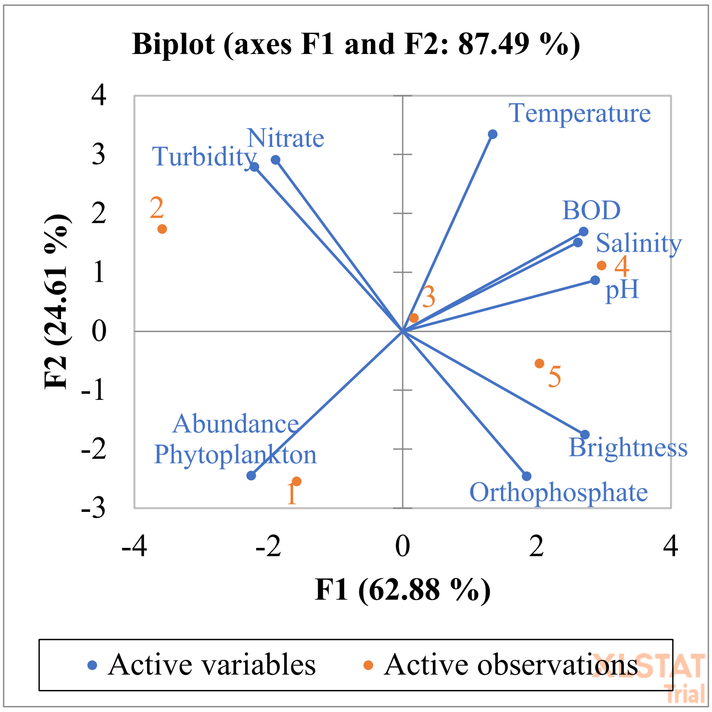

Figure 5. PCA Relationship Between Physical-Chemical Parameters with An Abundance of Phytoplankton

DISCUSSION

Phytoplankton Community Structure

Phytoplankton Abundance

Table 3 regarding the abundance of phytoplancon in East Plawangan Segara Anakan, Cilacap shows that the highest abundance is at station I, namely 3814 ± 939 ind/L, while the lowest abundance is at station IV, namely 840 ± 435 ind/L. Raymont (1963), stated that the abundance of phytoplankton in each region is classified into 3 (three) trophic levels of waters, namely: oligotrophic waters which have low fertility with a phytoplankton abundance of 0 - 2000 ind/L, mesotrophic waters which have medium fertility with a phytoplankton abundance of 2000 – 15,000 ind/L and eutrophic waters that have high fertility with an abundance of phytoplankton >15,000 ind/L. Based on this statement, it shows that the waters at stations I and II are included in the mesotrophic waters category, while at stations III, IV and V are included in the oligotrophic waters category.

Anthropogenic activities and the introduction of waste into surrounding waters will influence changes in environmental conditions and communities in these waters (Odum, 1993). There were fewer types of phytoplankton found at stations III, IV and V compared to stations I and II, this indicates that each type of phytoplankton has a different tolerance to environmental factors and at this station the distribution is not widespread. This is in accordance with the statement of Munirma *et al*. (2015), that variations in abundance at each station are caused by the ability of phytoplankton to adapt to environmental conditions so that the abundance between types will be different.

Diversity Index

The phytoplankton diversity index in East Plawangan Segara Anakan Cilacap shown in Figure 2 shows that the phytoplankton diversity value obtained in East Plawangan Segara Anakan, Cilacap ranges from 2.42 - 2.99. The highest diversity was at station II, namely 2.99, and the lowest diversity was at station V, namely 2.42.

The higher the diversity index value, the more diverse the plankton community in the waters will be (Arinardi *et al*., 1994). Odum (1994), states that if the diversity index value $H'<1.00$ indicates that the waters have high ecological pressure and low diversity, if the diversity index value $\leq 1.00 \leq H' \leq 3.00$ indicates a medium level of diversity and if the diversity index value $H' \geq 3.00$ indicates that the waters have low ecological pressure and a high level of diversity.

Differences in diversity index values are influenced by physical-chemical factors in these waters. This is in accordance with Reynolds (2006), that environmental factors that can influence phytoplankton diversity include temperature, brightness and nutrients. Each type of phytoplankton has a tolerance for different nutrient concentrations. The high diversity index value at station II is thought to be because at this station there is mangrove vegetation which supports the growth of phytoplankton. This is supported by the opinion of Odum (1994), who stated that a high diversity index indicates that the location supports the growth of plankton.

Evenness Index

Based on Figure 3**,** the evenness index value obtained ranges from 0.74 - 0.89. The highest evenness is at station II, namely 0.89, and the lowest evenness is at station I, namely 0.74. According to Radiarta (2013), the evenness index (E) value ranges from 0-1. The smaller the E value indicates that the evenness of a population is getting smaller. On the other hand, if the evenness value is close to 1, it indicates that the plankton population in the area is evenly distributed. This was confirmed by Yuliana (2015), who stated that if the evenness index value is more than 0.5, it indicates a stable plankton community.

Figure 3 indicates that the distribution of phytoplankton in East Plawangan is even, where the distribution of phytoplankton types found at each station is relatively the same. This is because each station has the same phytoplankton species. For example, the species *Chaeotoceros affinis*, *Coscinodiscus lineatus*, *Synedra ulna*, *Tabellaria* sp. and *Ulothrix* sp. This is in accordance with Handayani & Tobing (2008), that a high evenness index value indicates that the distribution of abundance of phytoplankton species in a community is relatively equal. According to Wiyarsih *et al.* (2019), the evenness index value is influenced by environmental factors such as nutrient availability and different nutrient utilization of each species, as well as the ability of phytoplankton to adapt.

Dominance Index

Based on the dominance index value obtained, it indicates that the phytoplankton found in East Plawangan is included in the low dominance level. This is in accordance with Odum (1994), if the dominance index value is in the category $0 < D < 0.5$, it indicates that the waters are included in the low dominance index category. This is confirmed by Pirzan & Rani (2008), that a dominance value close to 1 indicates that there is a dominant genus in the community. On the other hand, a dominance value that is close to 0 indicates that in the community structure there is no genus that is extremely dominant.

Based on Figure 4**,** the dominance index (D) value ranges between 0.06 - 0.14. The highest dominance is at station III with a value of 0.14, while the lowest dominance is at station

II, namely 0.06. The differences in the dominance index values obtained are due to differences in the species that dominate at each station. The species that dominates at station III is *Coscinodiscus radiatus* with a total abundance of 1105 ind/L.

C. radiatus is a phytoplankton belonging to the Chrysophyta division, where this class has high adaptive and reproductive abilities, and has cosmopolitan characteristics which cause organisms in this class to dominate in waters (Odum, 1998). Chrysophyta are characterized by cell walls that are strengthened by silica, this causes chryophyta to have a high tolerance for aquatic conditions (Dodds, 2002).

Physical-Chemical Parameters

The results of the analysis of physical-chemical parameters in East Plawangan show that the temperature at 5 stations was found to be between 27.7 - 30.1◦C. The highest temperature was at station IV, namely 30.17◦C, while the lowest temperature was at station I, namely 27.7◦C. Based on PP RI No. 22 of 2021, states that a good temperature for biota is 28 - 32◦C. This shows that station I does not meet quality standards, whereas according to Effendi (2003) the optimum temperature value for phytoplankton growth is 20 - 30◦C.

The salinity values obtained at 5 stations ranged from 15 – 27 ppt. The highest salinity is at station V, namely 27 ppt, while the lowest salinity is at station I, namely 15 ppt. These results are based on PP RI No. 22 of 2021 does not meet quality standards. The low salinity at 5 stations is caused by the influence of stirring and mixing of fresh water entering through river flows that flow into it. This is in accordance with the statement of Hutabarat & Evans (1984), who stated that estuarine waters are areas where salinity levels decrease due to the influence of incoming fresh water and tides occurring in the waters.

Brightness values at 5 stations in East Plawangan ranged from 42.3 – 76.5 cm. The highest brightness is at station IV, namely 76.5 cm and the lowest brightness is at station I, namely 42.3 cm. Based on PP RI No. 22 of 2021, a good brightness value for biota is >3 meters. This shows that the brightness values at 5 stations do not meet quality standards. According to Sheldon & Alber (2011) the level of brightness in estuarine waters that is good for biota is divided into three categories, namely good (>50 cm), medium (30 – 50 cm) and poor (<30 cm). The brightness values at 5 stations fall into the good and medium categories, so they are still good enough for the survival of phytoplankton.

The pH value obtained from each station in East Plawangan Segara Anakan Cilacap ranges from 7.48 – 7.85. The highest pH value is at station IV, namely 7.85, and the lowest is at station II, namely 7.48. Based on PP RI No. 22 of 2021, a good pH value for biota ranges from 7 – 8.5. According to Asriyana & Yuliana (2012), a good pH for the growth of phytoplankton in waters ranges from 6.5 - 8.0. This shows that the pH at each station meets quality standards.

The turbidity values obtained at 5 stations ranged from 12 – 44.5. The highest turbidity is at station II, namely 44.5, and the lowest turbidity is at station IV, namely 12. Based on PP RI No. 22 of 2021, a good turbidity value for biota is 5 NTU. This shows that the turbidity at 5 research stations does not meet quality standards. According to Yuliana (2014), turbidity is caused by high levels of suspended organic and inorganic materials such as mud, sand, plankton and microscopic organisms. Water turbidity can affect phytoplankton activity in carrying out photosynthesis.

The results of BOD measurements at 5 stations ranged from 3.9 – 10. The highest BOD value was at station IV, namely 10, and the lowest BOD value was at station 1, namely 3.9. Based on PP RI No. 22 of 2021, good BOD5 for biota is <20. This shows that these waters meet quality standards. BOD is the amount of dissolved oxygen needed by aquatic microorganisms to decompose organic matter aerobically (Hamuna *et al*., 2018). This organic material comes from industrial and domestic waste as well as plant decay.

The nitrate values obtained at 5 stations ranged from 5.48 – 6.55. The highest nitrate content was found at station II, namely 6.55, and the lowest nitrate content was at station I, namely 5.48. Based on PP RI No. 22 of 2021, the good nitrate content for biota is 0.06 mg/L. Thus, the nitrate content in East Plawangan waters exceeds quality standards. A high nitrate content indicates that the waters have high fertility. However, if it exceeds quality standards it can trigger rapid phytoplankton growth. This is in accordance with Effendi (2003) statement that if the nitrate content in waters exceeds 0.3 mg/L it will result in eutrophication of the waters.

The orthophosphate content at the 5 stations ranged from 0.09 – 0.11 mg/L. The highest orthophosphate content is found at stations III and V, namely 0.11, while the lowest orthophosphate content is at station II. Based on PP RI No. 22 of 2021, the good orthophosphate content for aquatic biota is 0.015 mg/L. According to Ulqodry *et al*. (2010), orthophosphate comes from the bodies of dead flora and fauna.

The Relationship Between Phytoplankton Abundance and Physical-Chemical Factors

PCA analysis shows that quadrant I is dominated by stations III and IV with characteristic physical-chemical parameters, namely salinity, pH, BOD and temperature. Station IV is located at the mouth of the Donan River. This river is used as a center for anthropogenic activities in East Plawangan, including Sleko Harbor which is used for community crossing traffic as well as several industrial activities such as PT. Solusi Bangun Indonesia Tbk and PT. Pertamina RU IV Cilacap.

Quadrant II is dominated by station II with characteristic physical-chemical parameters, namely turbidity and nitrate. Station II is located at the mouth of the Sapuregel River. This area contains rice fields and has a lot of mangrove vegetation. The Sapuregel River has a water area of ± 120 Ha (Sugiharto, 2005). The high turbidity value is thought to be caused by sediment movement in the river estuary area caused by the tides, this is in accordance with Haryono *et al*. (2014), where river estuaries have the potential for accumulation of fine particles such as mud due to tidal processes. During high tide, sea water will transport particles from the sea. Meanwhile, at low tide, river water moves to the estuary by transporting sediment, so that in the river mouth area accumulation occurs which will cause the turbidity concentration to be higher.

Quadrant III is dominated by station I with characteristic abundance of phytoplankton. Station I is located at the mouth of the Kembang Kuning River, this area has mangrove vegetation along the river flow. This river has a water area of ± 40 Ha (Sugiharto, 2005). The high abundance of phytoplankton at this station is thought to be due to the presence of mangroves in good condition. Saifullah *et al*. (2016), stated that the presence of mangroves will cause nutrient outwelling from mangrove and river sediments, this is a factor that supports the growth of phytoplankton so that the abundance of phytoplankton will be higher.

In quadrant IV, station V is dominated by physical and chemical parameter characteristics, namely brightness and orthophosphate. Station V is the confluence of the Kembang Kuning River, Sapuregel River and Donan River. In this area there is a port and industrial PT. Pertamina RU IV Cilacap. The high value of orthophosphate is thought to be due to the location of the station in an estuary and is influenced by industrial activities. This is in accordance with the statement of Puspitasari *et al*. (2021), who stated that high concentrations of orthophosphate are the result of human activities such as the disposal of household waste, industrial waste and fishing activities.

CONCLUSION

Based on the results obtained in this research, it can be concluded that Phytoplankton in East Plawangan Segara Anakan, Cilacap showed abundance in the low and medium categories with varying values, namely 840 ± 435 - 3814 ± 939 ind/L. The diversity index (H') shows that phytoplankton is in the medium diversity category with a value of 2.42-2.99, while the phytoplankton evenness index (E) is in the high evenness category with a value of 0.74-0.89. The dominance index (D) is in the low dominance category with a value of 0.06-0.14. Physical-chemical parameters in the form of temperature, salinity, brightness, pH, BOD still comply with quality standards, while nitrate and orthophosphate no longer meet quality standards based on PP RI. No. 22 of 2021. Analysis of the relationship between physical-chemical factors shows that the relationship between parameters and stations is dominated by two main factors, namely F1 and F2, which produce the largest variance value, namely 87.49%. Quadrant I is dominated by stations III, IV, temperature, BOD, salinity, pH. Quadrant II is dominated by station II, nitrate and turbidity. Quadrant III is dominated by station I and the abundance of phytoplankton. Quadrant IV is dominated by station V, brightness and orthophosphate.

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