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Key Species of Phytoplankton in Eastern Part of Segara Anakan Indonesia Based on Season

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ABSTRACT

Phytoplankton blooms are a problem that often occurs in estuarine and coastal ecosystems. The changes in phytoplankton community species composition, diversity, biomass, and distribution were caused by the conditions of seasonal and temporal variation. The immediate location of the estuary ecosystem is near cities, where rapid economic growth and human activity tends to increase the pressure on the environment. The purposes of this research were to evaluate the seasonal and temporal variation and to determine the key species of phytoplankton in the eastern part of Segara Anakan which can cause a bloom based on season. The samples of phytoplankton were taken from 6 sites during April – September 2019 when the highest tide occurred during the dry and rainy seasons. The community structure were performed using primer software Ver 5 to find the similarity and / or differences of the phytoplankton community structure based on season. Simper analysis was used to determine key species (phytoplankton species) based on season and location. The community structure of phytoplankton in Segara chicks were composed by 5 divisions. During the dry season, Bacillariophyta was dominant (82%), whereas during the rainy season, Bacillariophyta (43%) and Chlorophyta (31%) and Cyanophyta (25%) were the dominant species. This study shows that the phytoplankton community structure in this estuary presents the environment conditions during the rainy season that increase the abundance of phytoplankton, especially of the species which may thrive into blooms. The most important species was Oscillatoria limosa that had the highest percentage of contribution.

Keywords: phytoplankton, Segara Anakan, spatial and temporal variation.

INTRODUCTION

An estuary is a part of the coastal ecosystem which is directly connected to the sea. In an estuary, there is a mixture of marine and freshwater that enters the area through drainage either from the land or usually the river. Amri et al. (2019) stated that the estuary area contains fertile waters, because it is rich in nutrients which causes an abundance of phytoplankton as primary producers to provide food for a higher tropical level. On the basis of this ecological function, the condition of the phytoplankton community is often used as a measure of water fertility.

The eastern part of Segara Anakan estuarine waters is located near the city area with rapid economic growth, so that the Segara Anakan waters received the organic and inorganic waste from the domestic activities, factory, and other industries such as cement factory (Holcim) and oil industry (Pertamina) which may cause environmental disturbance and low quality in the aquatic area (Sulistiono, 2017). These human activities also cause increasing nutrients which trigger eutrophication marked by phytoplankton bloom. Phytoplankton blooms are a problem that often occurs in estuarine and coastal ecosystems. The changes in nutrient concentrations promoted the population growth of phytoplankton species at different time points during the year (Rojas-Herrera, 2012). The changes in composition, diversity, biomass, and distribution of phytoplankton community species were also influenced by the conditions of seasonal and temporal variation (Devlin et al., 2019). The temporal variation is a condition which is affected by time, like between the dry season and the rainy season where both of them may affect the physical and chemical condition in the water, such as the fluctuation depth and exposure which are influence by the rainfall intensity (Zulmi, 2018).

The dynamic variation and biogeochemical processes of nutrients in the estuary have a very complex influence by season (Egerton, 2013). The distribution and abundance of plankton in the estuary is influenced by tides, salinity, temperature, chemical content, hydrostatic pressure and season (Amri et al., 2019).

Season will affect the nutrient concentration, light penetration, salinity, low temperature, and turbidity (Rojas-Herrera, 2012). Changes in the nutrient concentration will change the structure of phytoplankton in the ecosystem and promote population growth at different points in time throughout the year (Menezes et al., 2013). Therefore, in order to find the ways to solve environmental problems of nutrient enrichment and eutrophication, as well as to develop new tools for devising the restoration strategies to address eutrophication, it is necessary to understand the eutrophication process, plankton production, and biological resources at the observation site (Egerton, 2013).

The purposes of this research were to evaluate the temporal variation of phytoplankton diversity and to determine the key species of phytoplankton in eastern part of Segara Anakan based on season. The results of this study can be used to estimate water fertility and monitor environmental changes. Key species can be used as indicators of environmental quality. The presence or absence of these key species can indicate that there has been a change in the environment.

RESEARCH METHOD

The research was conducted by using a survey method with purposive sampling technique in 6 locations during the dry and rainy seasons. The location of sampling are presented as in Figure 1. The sampling was conducted once a month in April, May, August, and September 2018.

The main parameters were the number of individuals and species of phytoplankton. The samples of phytoplankton were collected with a 2-L Van Dorn bottle monthly during the rainy (April, May 2019) and dry (August, September 2019) seasons in the euphotic zone (approximately 0.3–0.5 m below the surface) at each sites. The phytoplankton sampling was performed during the day at 10.00 AM, until approximately 3.00 PM. Up to 100 L of water were poured into a phytoplankton net for filtration, transferred to sample vials with 2–3 drops each of 4% formalin and Lugol's solution, and then sealed tightly to prevent spilling.

The results of phytoplankton identification in the laboratory were used to determine the species

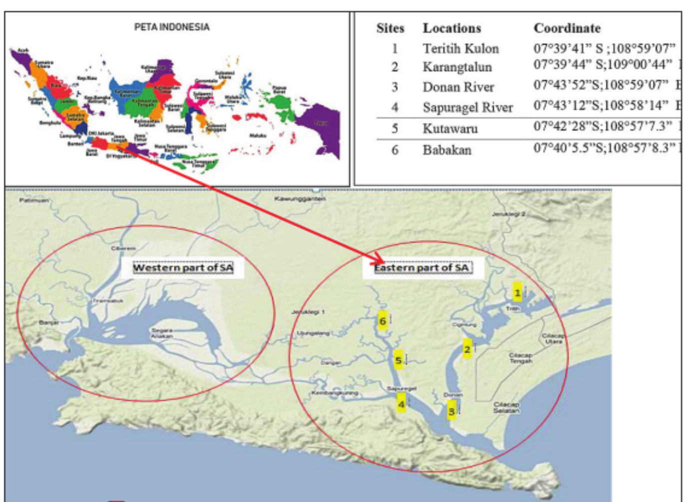

Figure 1. Research location of eastern Segara Anakan

richness and relative abundance and also the level of dominance for each species. The similarity/dissimilarity percentage were performed using primer software Ver 5 to find the similarity and/or differences of community structure of phytoplankton based on season. Furthermore, to determine the key species of phytoplankton, they were analyzed based on the percentage of contribution (%) in compiling the community based on season. Simper analysis was used to determine the key species (phytoplankton species) by season and location. The key species were determined based on the total accumulated abundance of 50% of the total abundance of the phytoplankton community at a predetermined time or location.

RESULTS AND DISCUSSIONS

Diversity and Abundance of Phytoplankton

The result of phytoplankton identification found that during the rainy season there were 58 species and the dry season 50 species with total abundance of 1695 ind.L^{-1} and 1133 ind.L^{-1}, respectively. It showed that in the rainy season, both the abundance and number of species were higher than in the dry season. In the rainy season, there were 5 divisions of phytoplankton, namely Bacillariphyta, Chlorophyta, Cyanophyta, Euglenophyta and Dinophyta. The dry season only consists of 3 divisions, namely Bacillariphyta, Chlorophyta, and Cyanophyta. Baccilariophyta is the most abundant division followed by Chlorophyta and Cyanophyta in both the rainy and dry seasons (Table 1 and Figure 2).

On the basis of the result of phytoplankton identification temporally between the dry and rainy season, found that during the dry season there were 33 species, composed by 6 Divisions: Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae, and Dinophyceae. During the dry season, the segara anakan water were dominated by phytoplankton of Bacillariophyceae up to 82% and 17.4% of chlorophyta (Figure 2).

The presence of cyanophyta shows that in the rainy season waters tend to be polluted, because the presence of cyanophyta indicates eutrophication. Cyanobacteria were only common in low salinity waters and occurred mostly at higher temperatures. Yan *et al.*, (2017) stated that climate warming and eutrophication are regarded as two important contributors to the occurrence of cyanobacteria blooms in aquatic ecosystems. The dry season was more dominated by Bacillariophyta. Their abundance showed increasing up to 82%. In that period, Chlorophyta also recorded an increase in percentage amounting to 17.4%. In the case of Cyanophyta, it was only 0.4%, whereas Euglenophyta and Dinophyta were not found during dry season (Figure 2).

During the rainy season, it was found that there were 5 divisions composed by Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyta and Dinophyceae. The 3 divisions of Bacillariophyta, Chlorophyta and Cyanophyta dominated the rainy season (Figure 3).

On the basis of its relative abundance, it can be seen that 3 genera make up the community of more than 10% during the rainy and dry season, namely *Oscillatoria, Asterionella, Chaetoceros*, and *Eudorina* (Table 2). The *Asterionella*, and *Eudorina* generea, are only abundant during the dry season, making up 21.18 % and 10.94% of the communities, respectively, while *Chaetoceros* and *Oscillatoria* are abundant during the rainy season in as much as 29.17% and 32.05%.

The phytoplankton species with the highest composition in the community in the rainy season were *Oscillatoria limosa*, *Chaetoceros*

Table 1. Diversity and Abundance of Phytoplankton based on season

Division	Number of species		Abundance			
	rainy	dry	rainy		dry	
			Ind.L^{-1}	%	Ind.L^{-1}	%
Bacillariophyta	42	43	736	43,43	933	82,35
Chlorophyta	8	4	517	30,53	193	17,06
Cyanophyta	4	3	429	25,33	4	0,35
Euglenophyta	1	0	3	0,16	0	0
Dinophyta	3	0	9	0,55	3	0,24
Total	58	50	1695	100	1133	100

Source : Asiddiqi *et al* (2019)

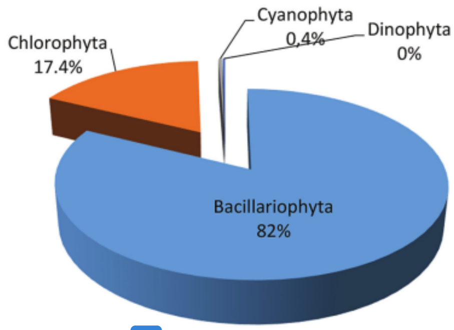

Figure 2. The abundance of phytoplankton at Segara Anakan during dry season

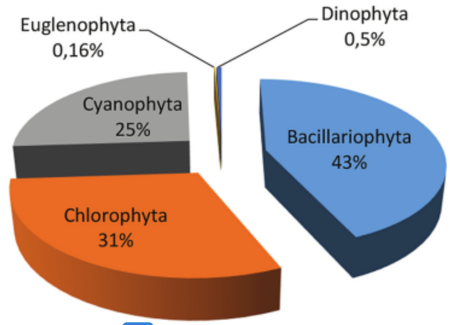

Figure 3. The abundance of phytoplankton at Segara Anakan rainy season

Table 2. The each percentage of plankton species in their communities

Species	Rainy		Dry	
	Relative Abundance %		*Relative Abundance %*	
Genus : Asterionella				
A. japonica	0,11	0,64	3,29	21,18
A. formosa	0,32		9,18	
Asterionella sp.	0,21		8,59	
A.lorenzianus	0,00		0,12	
Genus : Coscinodiscus				
C. marginatus	0,53	9,97	5,41	5,41
C. lineatus	8,44		0,00	
Genus : Eudorina				
E. elegans	0,00	0,00	10,94	10,94
Genus : Chaetoceros				
C. affinis	13,14	29,17	1,29	10,71
C. siacense	2,24		2,82	
C. senescense	0,00		0,71	
C. compressue	0,64		0,12	
C. dydymis	0,75		1,76	
C. lauderii	6,94		2,47	
C. weissflogii	0,00		0,94	
C. paeudocurvi	0,00		0,59	
C. diversus	0,53		0,00	
C. curvisetus	0,75		0,00	
C. brevis	4,17		0,00	
Genus Oscillatoria				
O. limosa	*30,13*	*32,05*	0,12	*0,12*
O. formosa	*1,92*		0,00	

*affin*is, *E. elegans* with 30.13% and C. *affinis* 13.14%, and 10.94% (Table 3). Cyanophyceae was commonly found in the lowest salinity, whereas *Ocsillatoria* is a cosmopolitan genus which can be found under almost every waters condition such as freshwater, brackish and marine. Diatoms constitute one of the most abundant and diverse phytoplankton groups, with is estimated to comprise 200,000 species. *Chaetoceros* is one of the largest genera of diatoms in the marine phytoplankton, and its many species are widely distributed, some even cosmopolitan (Li Y et al., 2017). *Oscillatoria* sp. is a microalgae that is included in the group of Cyanobacteria.

The phytoplankton from the Bacillariophyceae class, also known as Diatoms, were the most abundant during the study. It is well-known that diatoms are sensitive to a wide range of technological and environmental variables, and that their community structure may quickly respond to changing physical, chemical and biological conditions in the environment (Batsi *et al.*, 2012). The dominance of phytoplankton from the Bacillariophyceae class is a common occurrence at sea. This is attributed to the fact that the phytoplankton from this class are able to adapt to the environment in which they live, compared to other types. The many classes of Bacillariophyceae (Diatoms) in the waters, apart from their ability to adapt, are also cosmopolitan, resistant to extreme conditions and have high reproductive power. Liu *et al.*, (2014) stated that the phytoplankton commonly found in the sea are usually dominated by large ones, namely Diatoms and Dinoflagellates.

On the basis of a simper analysis using primer software 5, the differences in phytoplankton abundance at the six observation stations between the dry season and the rainy season were compared. The cluster analyses showed that there is a grouping of community structures in each site during dry and rainy seasons (Figure 4).

This indicated that both seasons (dry & rainy) had a significant influence towards the average abundance of phytoplankton. In order to further elaborate the comparison of differences in phytoplankton abundance temporally in the dry season at each sampling location, a simper (similarity percetage) analysis was performed. The results of the simper analysis of the season obtained between the rainy and dry seasons obtained a disimilarity of 95.87%. This shows that the seasons are composed by very different phytoplankton communities. There are 10 species of phytoplankton that play a role in differentiating these conditions (Table 3).

The results of enumeration based on the season showed that the dominant type of the phytoplankton community is *Oscillatoria limosa* (8.75%), which was found to be very abundant in the rainy season and less abundant in the dry season, so that it is the key species that makes the largest percentage contribution to support these differences. Other key phytoplankton species are the *Chaetoceros affinis, Coscinodiscus lineatus* and C. *marginatus*, *Eudorina elegans*, *Tabellaria* sp, and *Asterionella* sp., A. *formosa* and A. *japonica* geera (Table 3). The most common/dominant species of the *Oscillatoria limosa* has the highest percentage of contribution. This means that within one community of dry and rainy seasons, this species filled the community as large as 8.75%, among the dry and rainy seasons.

The results of phytoplankton enumeration between the sampling sites in each season showed a significant difference (Table 4 and Table 5).

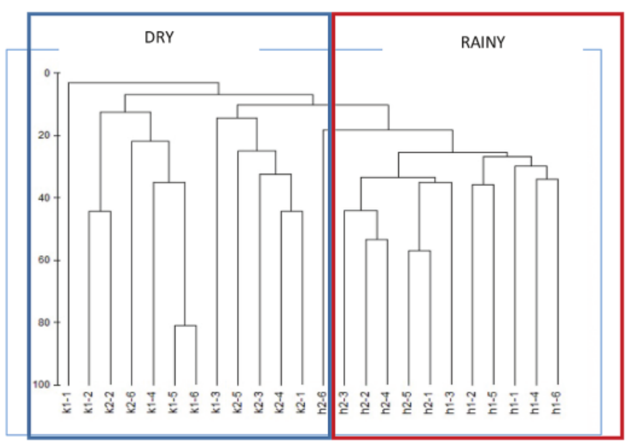

Figure 4. Clustering of Community Structure of phytoplankton between season.
Note : k : dry season h : rainy season

Table 3. Simper analysis of phytoplankton groups based on season

Spesies	Av.Abund		Av.Diss	Diss/SD	Contrib%	Cum.%
	Rainy	Dry				
Oscillatoria limosa	20,14	0,15	8,39	0,49	8,75	8,75
Chaetoceros affinis	12,21	1,00	6,59	0,72	6,87	15,63
Coscinodiscus lineatus	5,64	0,00	5,33	0,43	5,56	21,19
Eudorina elegans	0,00	7,31	5,07	0,59	5,29	26,48
Tabellaria sp	0,21	6,00	4,96	0,61	5,18	31,66
Asterionella fomosa	0,21	6,46	4,47	0,65	4,66	36,32
Asterionella japonica	0,07	6,54	3,68	0,52	3,84	40,15
Asterionella sp	0,64	5,62	3,49	0,64	3,64	43,79
Coscinidiscus marginatus	0,36	3,77	3,44	0,63	3,58	47,38
Average dissimilarity	95,83 %					

Table 4. Key species of phytoplankton during rainy season

Spesies	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chaetoceros affinis	12,21	2,49	0,41	28,30	28,30
Synedra accus	2,57	1,62	0,84	18,44	46,74
Average similarity (between locations)	8,78 %				

Tabel 5. Key species of phytoplankton during dry season

Spesies	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Tabellaria sp	6,00	1,98	0,36	11,20	11,20
Asterionella formosa	6,46	1,81	0,55	10,23	21,43
Eudorina elegans	7,31	1,69	0,44	9,55	30,98
Nitzschia sigma	3,92	1,69	0,69	9,54	40,52
Coscinidiscus marginatus	3,77	1,41	0,48	7,96	48,48
Average similarity (between locations)	17,70 %				

During the rainy it was shown that the phytoplankton community among the sampling sites exhibited a very significant difference of 91.22% with average similarity of 8.78% (Table 4). The key species of phytoplankton (species found in all locations) were *Chaetoceros affinis* (28.30%) and *Synedra accus* (18.44%).

The dissimilarity of phytoplankton structure among the sites during the dry season was very significantly different (83.3%). The average similarity among sites was 17.70% (Table 5). The key species were *Tabellaria* sp (11 %), *Asterionella formosa* (10.23%), *Eudorina elegans*, *Nitzchia sigma* (9.54%) and *Coscinodiscus marginatus* (7.96%).

The differences in phytoplankton communities between sites are caused by each location being influenced by different human activities around it.

CONCLUSIONS

The community structure of phytoplankton in Segara anakan were composed by 5 divisions. During the dry season, the dominant species was Bacillariophyta (82%), whereas during the rainy season, Bacillariophyta menurun (43%), Chlorophyta (31%), and Cyanophyta (25%) were the most abudnant.

The phytoplankton diversity was different both spatially and temporally. The areas that are relatively far from human activities were more diverse. Temporaly, the diversity during the dry season was more diverse than during the rainy season. The most common/dominant species was *Oscillatoria limosa* that had the highest percentage of contribution. Overall, this study shows that the phytoplankton community structure in this tropical stratified estuary presents the environment conditions during the rainy season that increase the abundance of phytoplankton that may thrive into blooms.

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