Abundance of Phytoplankton in The Coastal Waters of South Sumatera

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Abstract

Phytoplankton in the ocean has an important role in forming the base of food chain, responsible in primary production. Its abundance and number of phytoplankton species will indirectly affect the level of water's fertility. This study aimed to determine the presence of phytoplankton as bio-indicators of water quality in terms of abundance, diversity index, uniformity index, and saprobic coefficient in coastal waters of South Sumatera. The study was conducted at ten stations during high and low tides. Phytoplankton samples were taken vertically using plankton nets, cone-shaped with a diameter of 30 cm, length 100 cm and mesh size 30 μm. The study found 41 genera of phytoplankton, consisted of family Bacillariophyceae (26 genera), Dinophyceae (7 genera) Cyanophyceae (7 genera) and Chlorophyceae (1 genus). The highest number of genera was recorded while low tides in November (24 genera), and the lowest was on May while high tides (16 genera). The highest abundance of phytoplankton was recorded in August during high tides (2,68 x 10^7 cell.m^{-3}), and the lowest was in May during high tides (6,59 x 10^5cell.m^{-3}). The diversity index (H'), the uniformity index (E), and the dominance index (D) ranged between 0,64–3; 0,15–0,71 and 0,15–0,83, respectively.

Keywords: *phytoplankton, abundance, diversity index, South Sumatera coast.*

Introduction

The coast of South Sumatera receives water from large rivers, such as Musi and Banyuasin, and several other small rivers. In this region, from its upstream to downstream, communities use water for various activities such as for factories (fertilizer, rubber, oil), settlements, fishing, aquaculture, agriculture, farming, transportation and various other activities. These activities will increase the input of waste in the form of agricultural, domestic and industrial wastes. This may affect the life of organism in the water, one of them is phytoplankton, the primary producer in the trophic level of food chain in water.

Plankton, especially phytoplankton, has a particular important role in the food chain in aquatic ecosystems and is often used as indicators of stability, fertility and water quality. Phytoplankton can play a role as one of the ecological parameters, aquatic fertility, in describing the condition of a water body (Richardson, 2008).

Increasing activities in the coastal waters of South Sumatera will affect on the distribution abundance and diversity of phytoplankton, which also influence the water quality this region. According to Nybakken (1992) and Nontji (2005), aquatic organisms can be used as indicators of water quality because of their habitat, mobility, and age (relatively long) in inhabiting a water area. Basmi (2010) stated that the determination of aquatic biological index conducted generally from analysis study of phytoplankton community because they have high species diversity and abundance. Some previous phytoplankton studies have been done in this area, however, it was just done in certain month only, and do not represent the seasonal pattern of phytoplankton (Aryawati *et al*., 2005; Isnaini, 2011; Surbakti *et al*., 2011). This study aimed to assess the seasonal abundance and diversity of phytoplankton, and to evaluate the water quality of South Sumatera coastal waters through biological analysis study in terms of phytoplankton community as bio-indicator of water quality.

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Materials and Methods

Study sites

The study was conducted in the Banyuasin waters (South Sumatera) at 10 stations during high and low tides (Figure 1).

Phytoplankton sampling

Referring to Aquino *et al.* (2010) and Mulyani *et al.* (2012), phytoplankton sampling was conducted by using plankton nets with mesh size 30 µm, net mouth diameter 30 cm and net length 100 cm long. Sampling was done vertically from the depth of 2 meters to the surface of water. The filtrate, collected in the bucket, then was put into a sample bottle of 250 mL and was added with preservative, 4% formaldehyde (Edler and Elbrachter, 2010). All samples were stored in a cool place and protected from direct light beam to prevent color changing to the solution which can damage the sample.

Analysis of samples

Samples were collected and identified in the laboratory using a high power microscope (Nikkon Eclipse E400). The phytoplankton were identified to genus level by using the identification guide of Newell and Newell (1977); Yamaji (1984) and Tomas (1997). Phytoplankton enumeration was done by using the Sedgwik-Rafter Counting Cell on sample fraction, and the results are expressed in cell.m^{-3}. Analysis of phytoplankton abundance refers to the formulation used by APHA (1992). The species diversity of phytoplankton is known by the Shannon and Weaver's equation (1963). Diversity index is a mathematical representation or illustration depicting the structure of communities, and it can ease the analysis of data for the number and kinds of organisms. Diversity shows the number of gene variations or species in a body of water.

Uniformity index is used to determine the distribution pattern of biota. If the value is relatively high, the existence of any biota in the water is in even condition. Dominance index is used to determine the existence of a certain species dominance in the water. Uniformity index ranges between 0 to 1, the smaller the value of uniformity (near zero) indicates that the spread of each member from each species is not even. Conversely, if the uniformity value is greater (close to 1), the population shows uniformity (number of individuals of each genus can be said to be the same or not much different) (Odum, 1998). The uniformity index and dominance index of phytoplankton are calculated using the formula from Odum (1998). The dominance index values range between 0 to 1, where the smaller value indicates that there are no species that dominate, otherwise, the greater value shows the presence of certain species that dominate (Odum, 1998).

Results and Discussion

Species and abundance of phytoplankton

A species compositition can illustrate the diversity or the number of species in a community. This kind of diversity can increase if the community becomes more stable, and otherwise diminished when the environment is unstable or crashed. The identified phytoplankton populations in Banyuasin water were 41 genera. The composition of the genus was greatly found in the family Bacillariophyceae, then Dinophyceae, Cyanophyceae, and Chlorophyceae. The composition was dominated by 26 genera of diatom group, 7 genera of Dinophyceae, 7 genera of Cyanophyceae, and 1 genus of Chlorophyceae (Table 1).

At each month of observation, while on high tide or low tide, Bacillariophyceae was found to have the largest number of genera and abundance than other groups. This is because the class Bacillariophyceae is able to adjust to a diverse environmental condition compared to other classes. According to Arinardi *et al.* (1997), the class Bacillariophyceae adapted well to the environmental conditions, has high tolerance and adaptability, thus, this class is cosmopolitan. This situation is often found in Indonesian waters and territorial water in other regions (Haumahu, 2004; Fathi and Al-Kahtani, 2009; Rokhim *et al*., 2009; Ismunarti, 2013; Thoha and Aryawati, 2014).

Abundance is a measure of the number of individuals per unit volume of water which generally expressed in cells per unit volume. In general, the abundance of phytoplankton is closely linked to fertility or productivity of a waterbody. When the phytoplankton abundance is high, the water tend to have high productivity (Raymont, 1963).

Banyuasin's abundance of phytoplankton ranged between 6,59x10^5 to 4,21x10^7 cell.m^{-3}. In general, the abundance of phytoplankton was found slightly higher during low tide than high tide (Figure 2). The greatest abundance in every month of observation was found in group Bacillariophyceae then Dinophyceae, Cyanophyceae and Chlorophyceae. Genus *Chaetoceros* and *Skeletonema,* part of Bacillariophyceae family, were found to be the most abundant. Arinardi *et al.* (1997) stated that Bacillariophyceae members have

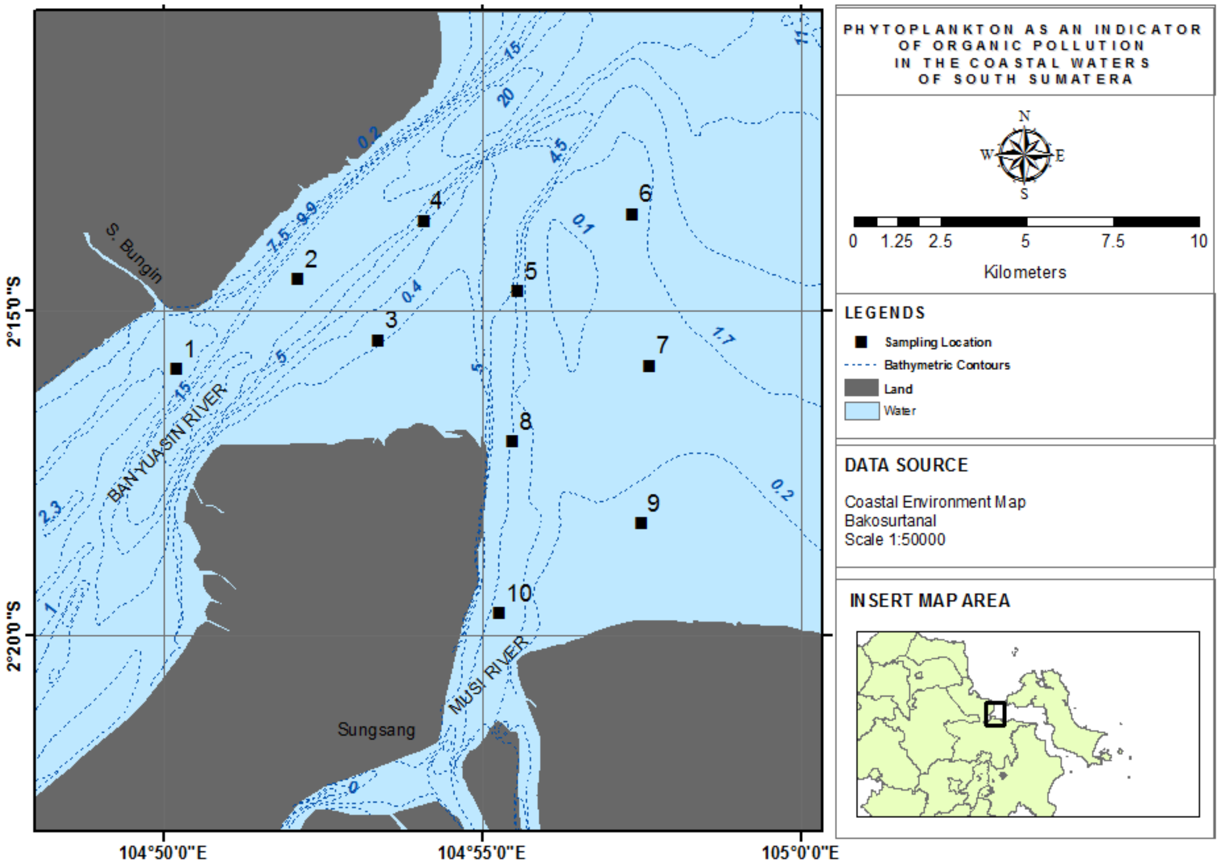

Figure 1. Map of study sites in the coastal waters of South Sumatera

higher reproducibility compared to other phytoplankton.

In August, *Chaetoceros* and *Skeletonema* gave the highest contribution to the phytoplankton abundance, so that the abundance of phytoplankton is commonly highest in this month. Both genera are often found in Banyuasin waters, and allegedly they play an important role there (Aryawati *et al*., 2005; Isnaini, 2011; Surbakti *et al*., 2011). In some waters in Indonesia both genera are also often found in large quantities (Soedibjo, 2006; Thoha, 2013; Thoha and Aryawati, 2014). Soedibjo (2007) showed that Jakarta Bay waters also showed a high abundance of *Skeletonema* and *Chaetoceros*, caused bythe high level of silicate, supplied from land through the rivers, supported also by temperature and salinity levels that exist. The genera are classified as phytoplankton commonly found especially in seasons with low rainfall (Praseno and Sugestiningsih, 2000).

Phytoplankton diversity

The results of the analysis for diversity index (H ') uniformity (E) and dominance (D) in the coastal waters of South Sumatera (Table 2 and Figure 3) showed that, in general, the waters belong to the less stable ones. In the months when certain water conditions are very good in terms of phytoplankton community structure (May high and low tides; November high; February high and low tides). In other months (August high and low tides; November low tide) showed unfavorable water conditions. Based on calculations, it was found that, in general, the month of May has excellent water conditions based on phytoplankton community structure, and the roughest water conditions was found in August. The same research results presented by Isnaini (2011) who conducted the research at Banyuasin river's estuary, which indicated that the phytoplankton community structure was in a better shape at transitional season (May) than the east season (July). These conditions were thought to be caused by environmental factors, existed at those times. In May, water conditions are suspected to be very conducive to the growth and proliferation of various types of phytoplankton, so that, a lot of phytoplankton can grow and proliferate, thus making species richness and abundance to increase. Differently, in August, supposedly the environmental conditions are not conducive to the growth and development of various types of phytoplankton, so that, only certain species can adapt, grow and

Table 1. Abundance of phytoplankton in the coastal waters of South Sumatera

No	Phytoplankton	May		August		November		February	
	(cell.m^{-3})	High tide	Low tide	High tide	Low tide	High tide	Low tide	High tide	Low tide
	Bacillariophyceae								
1	*Amphora*	0	0	0	0	0	0	4.247	708
2	*Asterionella*	0	0	0	46.450	0	0	0	0
3	*Bacillaria*	0	0	0	0	0	0	37.511	0
4	*Bacteriastrum*	22.650	4.954	104.388	50.244	7.786	38.556	21.232	15.571
5	*Chaetoceros*	206.658	141.558	15.582.485	2.628.478	94.140	150.383	60.158	48.845
6	*Coscinodiscus*	3.539	9.909	144.021	43.171	10.617	1.416	51.666	28.318
7	*Dictyliosolen*	0	0	1.415	0	2.123	9.909	0	0
8	*Diploneis*	0	0	0	2.123	0	0	0	0
9	*Dytilum*	9.201	10.618	56.971	37.734	2.123	3.539	8.493	4.247
10	*Eucampia*	0	0	18.047	16.985	0	24.065	0	0
11	*Guinardia*	708	0	12.385	9.435	14.156	22.994	1.416	2.124
12	*Hemidiscus*	0	1.416	1.415	0	0	0	0	0
13	*Hemiaulus*	0	1.416	147.913	0	12.033	4.955	2.831	0
14	*Lauderia*	0	0	171.622	212.058	8.494	28.307	2.123	0
15	*Leptocylindrus*	0	0	4.246	46.685	4.246	0	6.370	0
16	*Mellosira*	0	8.494	0	0	0	0	0	0
17	*Nitzschia*	27.602	81.408	164.545	145.530	54.150	38.924	67.236	31.150
18	*Odontela*	2.123	1.416	67.941	27.125	2.124	1.416	18.402	4.955
19	*Pleurosigma*	0	0	1.415	0	0	0	708	0
20	*Planktoniella*	0	0	0	0	0	2.831	0	0
21	*Podocystis*	0	0	0	0	1.770	28.325	0	0
22	*Rhizosolenia*	6.370	9.202	115.005	79.245	22.650	9.201	21.233	14.866
23	*Skeletonema*	175.498	147.225	8.686.175	38.174.782	207.738	1.839.466	627.769	327.809
24	*Surirella*	708	3.539	0	0	708	2.831	6.370	15.576
25	*Synedra*	0	0	0	0	0	0	708	0
26	*Thalassiosira*	67.948	133.807	409.416	251.446	53.091	91.294	323.444	101.222
27	*Thalassiothrix*	16.280	48.853	1.012.039	169.329	16.634	18.747	352.464	55.921
	Dinophyceae								
28	*Alexandrium*	0	0	2.831	0	0	0	0	0
29	*Ceratium*	3.538	0	0	0	0	2.477	10.616	4.247
30	*Dictyocha*	0	0	1.415	0	0	0	0	0
31	*Dinophysis*	2.831	1.416	2.123	9.908	9.910	9.201	708	0
32	*Noctiluca*	0	0	0	0	194.289	203.111	0	0
33	*Prorocentrum*	0	0	0	0	0	708	0	2.833
34	*Protoperidinium*	18.403	3.539	16.631	12.263	5.663	10.263	2.831	708
	Cyanophyceae								
35	*Anabaena*	0	19.818	74.310	99.750	0	0	0	0
36	*Holopedium*	0	0	0	0	0	89.174	0	0
37	*Microcystis*	0	0	0	0	0	0	0	25.484
38	*Nostoc*	0	0	0	0	1.062	0	0	0
39	*Oscillatoria*	94.845	82.119	0	0	0	11.324	372.272	156.417
40	*Spirulina*	0	708	0	21.933	0	0	0	0
	Chlorophyceae								
41	*Staurastrum*	0	0	0	0	0	0	0	708
Abundance (individual)		658.904	711.415	26.798.755	42.084.673	725.507	2.643.417	2.000.806	841.707
Genera		16	19	23	20	21	25	23	19

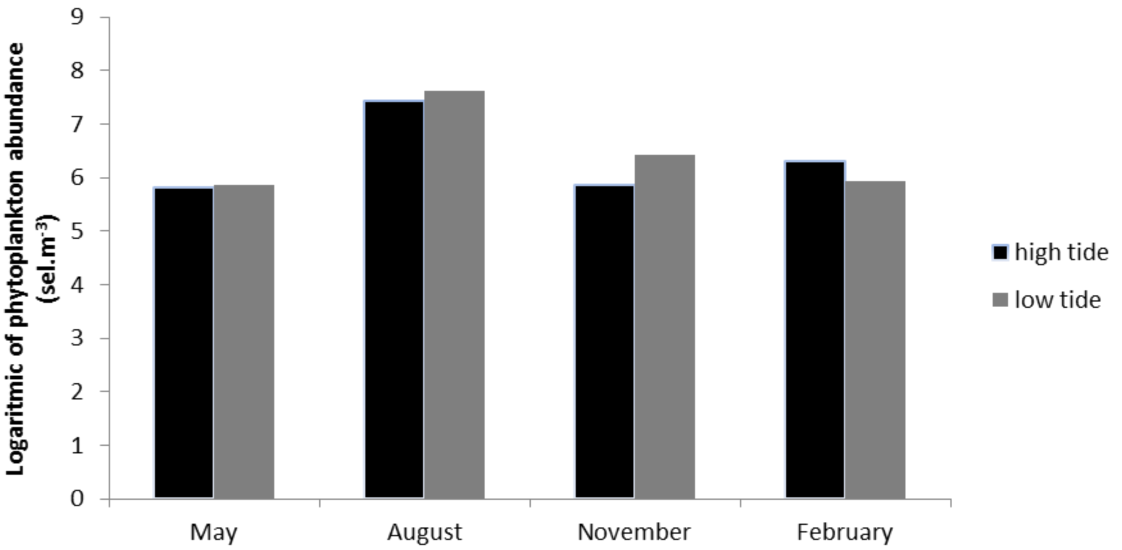

Figure 2. The abundance of phytoplankton in the coastal waters of South Sumatera (high tide: 6,59x10^5 cells.m^{-3} on May, 2,7x10^7 cells.m^{-3} on August, 7,26x10^6 cells.m^{-3} on November, 2x10^6 cells.m^{-3}on February 3rd; low tide; 7,11x10^5 cells.m^{-3} on May, 4,21x10^7 cells.m^{-3} on August, 2,64x10^6 cell.m^{-3} on November, 8,42 x 10^5 cells.m^{-3} on February) **Note.** ■ : high tide, ■ : low tide

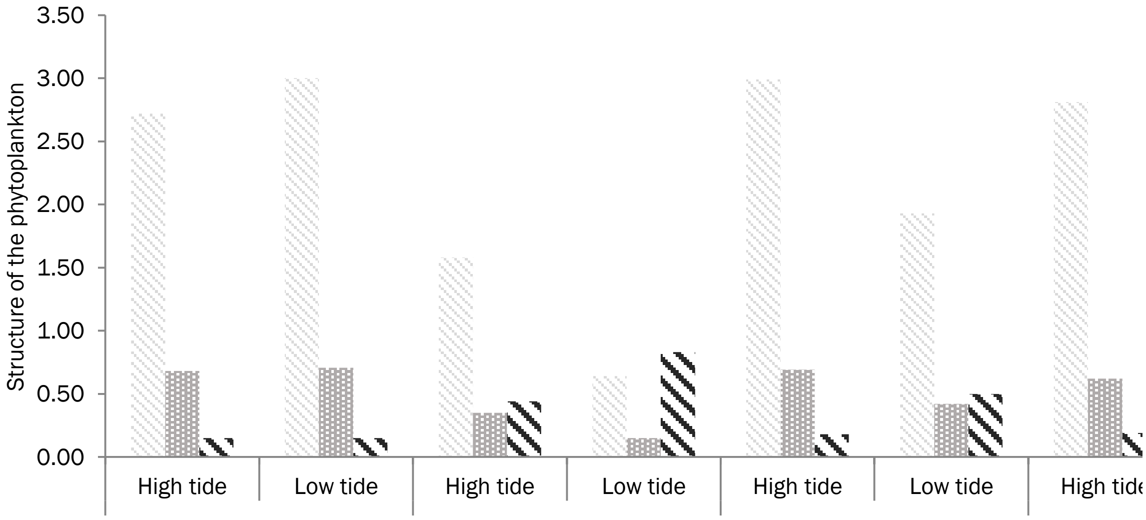

Figure 3. The structure of the phytoplankton community in the coastal waters of South Sumatera
Note. . Diversity (H'), : Uniformity (E), : Dominance (D)

Table 2. Phytoplankton community structure in the coastal waters of South Sumatera

Month of Observation	May		August		November		February	
	High tide	Low tide	High tide	Low tide	High tide	Low tide	High tide	Low tide
Diversity (H')	2,72	3,00	1,58	0,64	2,99	1,93	2,81	2,85
Uniformity (E)	0,68	0,71	0,35	0,15	0,68	0,42	0,62	0,67
Dominance (D)	0,15	0,15	0,44	0,83	0,18	0,50	0,19	0,21

develop properly in those conditions. Moreover, in terms of phytoplankton which usually be found, *Chaetoceros* and *Skeletonema*are found to be dominated. This happens because the member of these groups are able to survive in extreme conditions. According to Basmi (2010), the members of phytoplankton from division Chrysophyta (class Bacillariophyceae) are cosmopolitan, have properties that easily adapt to the environment, resistant to extreme conditions and highin reproduction.

Widiarti (2000) research results indicated that *Skeletonema* was positively correlated with phosphate in waters, while *Chaetoceros* like low salinity, and *Pyrodinium* like salinity and high nitrate content. Lagus *et al.* (2004) reported that diatoms (*Chaetoceros wighamii* and *Skeletonema costatum*) have a very quick response to the addition of nutrients, thus become dominant groups. A research conducted by Hasani *et al*. (2012) showed that there is a strong positive correlation between the concentration of nutrients N and P with the potential emergence of phytoplankton at different aquaculture locations in Lampung Bay. Pednekar *et al.* (2012) suggest that the abundance of phytoplankton species was associated with the increased nutrients that enter coastal waters from the mouth of river. No less important, the factor that triggering algal bloom is the reduced predation by herbivores (Lindahl and Dahl, 1990). Conditions such as these were suspected to affect the number of species and abundance of phytoplankton in the coastal waters of Southern Sumatera, thereby affecting phytoplankton community structure which ultimately affected water conditions in general.

Water quality conditions in the coastal water South Sumatera

Based on the results of measurements of water parameters in the study area, the sea water temperature ranged from 27,6 to 31,9; salinity from 0,09 to 33,05; pH 6,0 to 8,5; dissolved oxygen from 3,49 to 8,22 mg.L$^{-1;}$ phosphate 0,020 to 1,110 mg.L^{-1}; nitrates from 0,64 to 3,98 mg.L^{-1}, silicate from 0,001 to 0,430 mg.L^{-1}. Environmental parameter values in the coastal waters of the South Sumatra, is generally considered to be still feasible for the growth of phytoplankton.

The temperatures of the sea water in this study were generally higher in the dry and rainy season but decreased in transition. The results of measurements in these waters showed that the value of the parameter in sea water temperature is still support for the growth of phytoplankton. The pH value in these waters has similarities with some of the of Indonesia waters (Soedibjo, 2006; Prianto *et al.,* 2013). Generally, pH in ocean and coastal waters ranging from 7,70 to 8,4.

DO levels measured in this study ranged from 3,49 to 8,22 mg.L$^{-1.}$. According to Wardhana (1995), this range is still enough to support life aquatic organisms normally because it has a value of more than 2 mg.L^{-1}. These results also have similarities with studies conducted in other Indonesia waters (Sembiring *et al.*, 2012). One of the factors that may affect the levels of dissolved oxygen in seawater is the inclusion of waste which needed much oxygen in its decaying process. This type of waste usually comes from people's activities.

Direction and speed of currents in these waters varied from the mouth of the river up to the offshore. Speed of currents at high tide or low tide, has a value of 0,009-1,141 m.s^{-1}. The variations of water flow affects to the variations in the distribution of phytoplankton. Romimohtarto and Juwana (2004) states that the very small size of phytoplankton resulted on its movement much depend on the movement of water.

Nitrate concentrations obtained from the measurement results on the study sites showed a high value. Based on the KepMenLH No. 51-2004, the quality standard of sea water nitrate concentrations eligible to marine life is 0,008 mg.L^{-1}. The high nitrate in these waters is likely to be influenced by the input mass of water from several rivers that carry many nutrients nitrate. This is similar to other research done Risamasu and Prayitno (2011) that found high nitrate concentrations exceeding the threshold value of the exposure limit (standard quality) in Matasiri Islands waters, South Kalimantan. The high nitrate concentrations, indicating the enrichment of nitrogen by the influence of the mass of water enter the Barito River that carries nitrogen compounds from land to sea. High concentrations values of nitrate exceeding the threshold quality standards has also been demonstrated by Isnaini (2014) in the waters around the Maspari Island, Ogan Ilir, South Sumatra (1-2,1mg.L^{-1}) and Handoko *et al.* (2013) in Karimunjawa, Central Java (0,108-1,595 mg.L$^{-1.}$).

Phosphate concentrations obtained in this study had a high value and exceeds the quality standard limits as defined in KepMenLH. KepMenLH No. 51-2004 mentioned that the quality standard of maximum concentration of phosphate eligible to marine life is 0,015 mg.L^{-1}. Compared with some research in the other territorial waters of Indonesia, the concentration of phosphate in this region is higher than the Takalar waters, South Sulawesi ranged from 0,319 to 0,336 mg.L^{-1} (Pirzan & Pong-Masak, 2008), and Kwanyar waters, Bangkalan from 0,05 to 0,96 mg.L^{-1} (Rokhim *et al,.* 2009). Otherwise, it has lower value when compared with Karimunjawa Islands, Central Java from 1,769-4,030 mg.L^{-1} (Handoko *et al.,* 2013).

The content of silicate in the coastal waters of South Sumatera during the study ranged from 0,001 to 0,430 mg.L^{-1}. These results are similar to studies conducted by Tambaru (2008) in the coastal waters of Maros, South Sulawesi, but lower than researched Simanjuntak (2007) in Jakarta Bay. Temporally, the concentration of silicate in the coastal waters of South Sumatra was higher at the end of the dry season until the beginning of the rainy season. These results are similar to studies conducted by Lukman *et al.* (2014) in the coastal waters of South Sulawesi. According to the seasons, the concentration of silicate in the dry season is lower than the rainy season. Generally, the environmental conditions in the coastal waters of South Sumatra is still support for the growth and distribution of phytoplankton.

Conclusion

The study found 41 genera of phytoplankton, consisted of family Bacillariophyceae (26 genera), Dinophyceae (7 genera) Cyanophyceae (7 genera) and Chlorophyceae (1 genus). The highest number of genera was recorded while low tides in November (24 genera), and the lowest was on May while high tides (16 genera). The highest abundance of phytoplankton was recorded in August during high tides (2,68 x 10^7 cell.m^{-3}), and the lowest was in May during high tides (6.59 x 10^5cell.m^{-3}). The diversity index (H'), the uniformity index (E), and the dominance index (D) ranged between 0,64-3; 0,15-0,71, and 0,15-0,83, respectively.

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