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Harmful Algal in Banyuasin Coastal Waters, South Sumatera

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Abstract

Phytoplankton have important as food-chain major component and primary production of marine environment. However, high abundance of phytoplankton could give harmful effects toward water ecosystem. Moreover, they could produce toxic substances that will be accumulated within their consumer. This accumulation could be dangerous for human or animals.This research were aimed to determine and calculatespecies of harmful algae in Banyuasin coastal waters. The study was conducted on April, June, August, October and December of 2013, and in February 2014, at ten stations. Phytoplankton samples were taken vertically using plankton nets. In the form of cone-shaped with a diameter of 30 cm, length 100 cm and mesh size 30 μm.The result showed that there are 35 genera of phytoplankton. That have been found and consisted of four groups; Bacillariophyceae, Dinophyceae, Cyanophyceae and Chlorophyceae. 13 species were identified as Harmful Algal (Chaetoceros, Coscinodiscus, Nitzschia, Skeletonema, Thalassiosira, Alexandrium, Ceratium, Dinophysis, Noctiluca, Protoperidinium, Prorocentrum, Anabaena dan Oscillatoria), with seven of them were known for having toxin (Nitzschia, Alexandrium, Dinophysis, Protoperidinium Prorocentrum, Anabaena and Oscillatoria). Monitoring result showed that the highest number of species of potential harmful algal blooms (HABs) occured in June and the highest abundance occured in August, especially Chaetoceros and Skeletonema.

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INTRODUCTION

Phytoplankton serve as primary producer of aquatic food web, and hence become crucial organism for all aquatic life. In other side, some phytoplankton species can produce toxins that harm to organisms, such as animals and humans (Anderson et al., 2002; Anderson et al., 2010). In addition, the excessive alga population may result in severe aquatic environment. For instance, the death of algae which sink to the water's bottom will stimulate the growth of decomposer bacterium that exhaust dissolved oxygen concentration and lead to anoxic condition. This condition may kill many fish and cause the disruption of food web due to the replacement of some organism with other organisms, specially the ones with better endurance.

Algal bloom is a rapid increase in the population of algae in water system. Pednekar (2012) stated that during algal bloom, the phytoplankton density reached 10^6cells.m^{-3}for small sized phytoplankton. Harmful Algal Blooms (HABs) could be defined as overgrowths of algae that usually produce dangerous toxins in fresh or marine water.

Hallegraeff (1995) classified HABs into three groups. The first group is characterized by their ability to change the water column, then reduce the dissolved oxygen and thus harmful for aquatic organisms, i.e: dinoflagellata *Gonyaulax polygramma, Noctiluca scintillans, Scrippsiella trochoidea,* cyanobacterium *Trichodesmium erytrhraeum.*The second group is algae that produce toxin and harmful for human, i.e: dinoflagellata *Alexandrium acatenella, A. Tamarense, Gymnodinium catenatum, Pyrodinium bahamense,Dinophysis acuta*, *D. acuminata, D. rotundata, Prorocentru lima,* diatom *Pseudo-nitzschia multiseries, P. Australis,* cyanobacteria *Anabaena circinalis, Nodularia spumigena.* The third group is algae that do not harmful for human but endanger for marine organism due to impair and clog the marine organism respiratory system (gills fishes), i.e: diatom *Chaetoceros convolutus* and dinoflagellata *Gymnodinium mikimotoi*. Those species were commonly found in tropical area, including Indonesia (Praseno & Sungestiningsih, 2000).

It is unclear what kind of condition can cause HABs. It could be the impact of over load nutrient or climate change toward the algae growth (Anderson et al.,2002; Sellner et al., 2003; and Pednekar et al., 2012). (Anderson et al., 2002). Furthermore, some scientist point out that the occurences of HABs species were related to climate condition that affect aquatic environment such as salinity, temperature, current, nutrient, seasonal pattern and geomorphology condition. (Tan et al., 2006 and Tilstone et al., 1994 *in* Pednekar et al., 2012). Makmur (2008) expressed that HABs are resulted from coastal upwellingand possibly supported by high nutrient input, suitable temperature, oxygen availability, and suitable light intensity.In addition, HABs can be activated by the decrease of predator of herbivore (Danielsdottir et al., 2007).

Banyuasin water as the river mouth of two big river in South Sumatera (Musi River and Banyuasin River) has potential condition to stimulate HABs disaster. Previous studies has found some HABs species in the coast of South Sumatera like *Ceratium*, *Pseudonitzschia*, *Skeletonema* with total density of each was $0,5.10^3$ cells.m^{-3}, 1.10^3cells.m^{-3}, and $1.323.10^6$cells.m^{-3} respectively, whereas nutrien concentration was 0.015 – 0.145 mg.L^{-1} for nitrate and 0.003 – 0.054 mg.L^{-1}for phosphate (Aryawati et al., 2005). In 2011, Surbakti et al., also found two potential HABs diatom (*Pseudonitzschia* and *Skeletonema*) and four toxic dinoflagellata (*Ceratium, Dinophysis, Gymnodinium* and *Pyrodinium*) with nitrate, phosphate, and ammonia concentration were 2.8 mg.L^{-1}; 0.01 – 2.25 mg.L^{-1}, and 0 – 0.05 mg.L^{-1}, respectively.

Those previous studies indicated tendency of HABs increasing number and density. This phenomena probably could be related with increasing of nutrient concentration. Prianto (2010) reported the high nutrient concentration in Musi River up to 8 mg.L^{-1},0.05-1.54 mg.L^{-1}, and 0,1– ,26 mg.L^{-1} for nitrate, nitriteand ammonia, respectively. The similar high nutrient consentration in South Sumatera Coastal was also found by Isnaini (2014a), i.e. 1,0-2,1 mg.L^{-1} , 0.22-0.31mg.L^{-1} and 0.03-0.07 mg.L^{-1} for nitrate, phosphate and ammonia, respectively.

Due to previous study that was done on July-August, our research will extend more detail information about possibility of HABs in Banyuasin Water of South Sumatera. It is important to investigatethe current condition of Banyuasin Water that is potential to induce HABs, so that we can reduce their harmful effects.

METHODS

Sampling Area

The sampling was carried out in Banyuasin water, South Sumatera on April, June, August, October, December 2013, and February 2014, which will be then mentioned as a series of 1st month to 6th month. Ten sampling stations were arranged in the river mouth by using *purposive random sampling*, distributed from river side to the sea side (Figure 1).

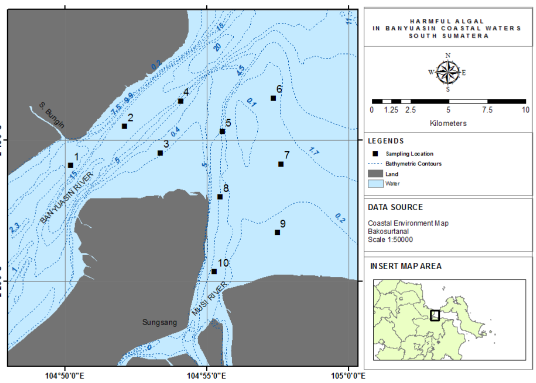

Figure 1. Location of research stations in Banyuasin Water

Data Collection

Sample of phytoplankton, referring to Aquino et al. (2010) and Mulyani et al. (2012) was collected vertically within 2 m depth of water surface by using plankton net with a diameter of 30 cm, long of 100 cm, and mesh size of 30 µm Phytoplankton samples were kept in the sample bottle (250 ml) and preserved with 4% formaldehyde (Edler & Elbrachter, 2010).

Phytoplankton was observed by using microscope equiped by Sedgwick Rafter Counting Cell (SRCC). Phytoplankton was identified by referring several manual books of plankton identification (Yamaji, 1966; Tomas, 1997). The phytoplankton abundance was calculated based on APHA formula (APHA, 1992).

Physicochemical Properties of the Environment

In addition, the water parameters such as temperature, salinity, and turbidity were measured *in situ by* CTD (Conductivity Temperature Depth). Water sample for nitrate and phosphate analysis was collected by water sampler, poured into the 250 ml bottle sample and kept in a *coolbox*. Measurement of nitrate and phosphate concentration was done by referring SNI procedures (2004) by using spectrophotometry.

Data Analysis

Data of phytoplankton and water parameters was analyzed using MS Excel in Table or Graph forms.

RESULTS AND DISCUSSION

Phtoplankton Species

A number of 35 phytoplankton genera were identified in Banyuasin water which can be categorized into four groups, i.e: Bacillariophyceae (26 genera), Dinophyceae (6 genera), Cyanophyceae (2 genera) dan Chlorophyceae (1 genus) (Table 1). Some species such as *Bacteriastrum, Chaetoceros, Coscinodiscus, Nitzschia,Rhizosolenia, Skeletonema*, *Thalassiosira, Thalassiothrix* and *Protoperidinium* were found frequently. These species are common phytoplankton species in South Sumatera coast (Aryawati et al., 2005; Isnaini et al., 2012), also in Indonesia water and other territorial regions (Haumahu, 2004; Fathi & Al-Kahtani, 2009; Rokhim, et al., 2009; Ismunarti, 2013; Thoha & Aryawati, 2014).

Chaetoceros was found every month probably due to their high adaptation level. Morphologycally, *Chaetoceros* has many setae, and large size. It commonly lives in colonies. Furthermore, *Skeletonema* and *Thalassiosira* also have high adaptation to environmental condition that might be supported by living in colony and long-chain cells. Thoha (2003) also found dominant diatom of *Chaetoceros, Thalassionema* and *Thalassiothrix* in Riau islands water, and dominant dinophyceae of *Ceratium*. The phytoplankton abundance of Banyuasin water was represented in Table 2.

Table 2 showed that Bacillariophyceae have the highest number of genera. This result is similar to some previous studies by Aryawati et al. (2005); Surbakti et al. (2011); Isnaini et al. (2012); Isnaini et al. (2014a); and Isnaini et al. (2014b). Tomas (1997) point out that Bacillariophyceae could distribute widely, live in different habitat and tend to become dominant algae in an open sea, coastal, and estuarine area. Bacillariophyceae domination was probably due to its higher reproduction rate than Dinophyceae or other phytoplankton groups. 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. Diatom could reproduce three times in 24 hours as nutrient increase, but only once in 24 hours for Dinophyceae (Praseno & Sugestiningsih, 2000).

The Possible Occurence of HABs

As being described in the pevious paragraphs, several phytoplankton categorized as

Table 1. Identified phytoplankton in Banyuasin water

No	Phytoplankton	Months					
		1st	2nd	3rd	4th	5th	6th
	Bacillariophyceae						
1	*Amphora*	+	-	-	+	-	+
2	*Asterionella*	-	-	-	-	+	-
3	*Bacillaria*	-	-	-	-	+	+
4	*Bacteriastrum*	+	+	+	+	+	+
5	*Chaetoceros*	+	+	+	+	+	+
6	*Coscinodiscus*	+	+	+	+	+	+
7	*Dictyliosolen*	+	-	+	-	-	-
8	*Dictyocha*	-	-	+	+	-	-
9	*Dytilum*	-	+	+	+	+	+
10	*Eucampia*	-	-	+	-	-	-
11	*Guinardia*	-	+	+	+	+	+
12	*Hemidiscus*	-	+	+	+	+	-
13	*Hemiaulus*	+	-	+	+	+	+
14	*Lauderia*	-	+	+	+	-	+
15	*Leptocylindrus*	+	+	+	-	-	+
16	*Mellosira*	-	-	-	+	+	-
17	*Nitzschia*	+	+	+	+	+	+
18	*Odontela*	-	+	+	+	+	+
19	*Pleurosigma*	-	-	+	+	-	+
20	*Podocystis*	-	-	-	+	-	-
21	*Rhizosolenia*	+	+	+	+	+	+
22	*Skeletonema*	+	+	+	+	+	+
23	*Surirella*	+	+	-	-	+	+
24	*Syendra*	-	-	-	-	-	+
25	*Thalassiosira*	+	+	+	+	+	+
26	*Thalassiothrix*	+	+	+	+	+	+
	Dinophyceae						
27	*Alexandrium*	-	-	+	+	-	-
28	*Ceratium*	-	+	-	-	+	+
29	*Dinophysis*	-	+	+	-	-	+
30	*Noctiluca*	+	-	-	-	+	-
31	*Prorocentrum*	+	-	-	-	+	-
32	*Protoperidinium*	+	+	+	+	+	+
	Cyanophyceae						
33	*Anabaena*	-	+	+	-	-	-
34	*Oscillatoria*	-	+	-	-	-	+
	Chlorophyceae						
35	*Staurastrum*	-	-	-	-	+	-
number of genera		16	20	24	21	22	23

Note : + : found; - : not found

Table 2. The phytoplankton abundance (cells.m^{-3}) from Banyuasin water

No	Phytoplankton	Abundance (cells.m^{-3})					
		1st	2nd	3rd	4th	5th	6th
	Bacillariophyceae						
1	*Amphora*	708	0	0	1.345	0	4.247
2	*Asterionella*	0	0	0	0	21.234	0
3	*Bacillaria*	0	0	0	0	5.662	37.511
4	*Bacteriastrum*	9.910	2.831	104.388	21.165	12.740	21.232
5	*Chaetoceros*	42.824	30.434	15.582.485	12.742	96.970	60.158
6	*Coscinodiscus*	2.831	25.480	144.021	70.219	21.234	51.666
7	*Dictyliosolen*	29.019	0	1.415	0	0	0
8	*Dictyocha*	0	0	1.415	1.416	0	0
9	*Dytilum*	0	32.558	56.971	1.274	2.123	8.493
10	*Eucampia*	0	0	18.047	0	0	0
11	*Guinardia*	0	2.831	12.385	1.699	1.416	1.416
12	*Hemidiscus*	0	1.416	1.415	425	1.416	0
13	*Hemiaulus*	709	0	147.913	1.274	1.416	2.831
14	*Lauderia*	0	33.265	171.622	2.548	0	2.123
15	*Leptocylindrus*	2.831	7.786	4.246	0	0	6.370
16	*Mellosira*	0	0	0	425	21.943	0
17	*Nitzschia*	21.587	44.805	164.545	12.883	40.345	67.236
18	*Odontela*	0	10.617	67.941	4.247	2.123	18.402
19	*Pleurosigma*	0	0	1.415	4.247	0	708
20	*Podocystis*	0	0	0	425	0	0
21	*Rhizosolenia*	2.831	4.247	115.005	3.044	1.416	21.233
22	*Skeletonema*	1.776.438	563.331	8.686.175	96.694	377.259	627.769
23	*Surirella*	708	708	0	0	1.416	6.370
24	*Syendra*	0	0	0	0	0	708
25	*Thalassiosira*	35.036	115.153	409.416	216.108	69.367	323.444
26	*Thalassiothrix*	23.357	48.837	1.012.039	11.609	18.402	352.464
	Dinophyceae						
27	*Alexandrium*	0	0	2.831	2.831	0	0
28	*Ceratium*	0	1.416	0	0	12.033	10.616
29	*Dinophysis*	0	5.416	2.123	0	0	708
30	*Noctiluca*	708	0	0	0	21.235	0
31	*Prorocentrum*	2.832	0	0	0	1.416	0
32	*Protoperidinium*	5.662	10.617	16.631	3.822	4.954	2.831
	Cyanophyceae						
33	*Anabaena*	0	33.973	74.310	0	0	0
34	*Oscillatoria*	0	14.868	0	0	0	372.272
	Chlorophyceae						
35	*Staurastrum*	0	0	0	0	708	0

Note: genera name with underline mark represent the HABs genera

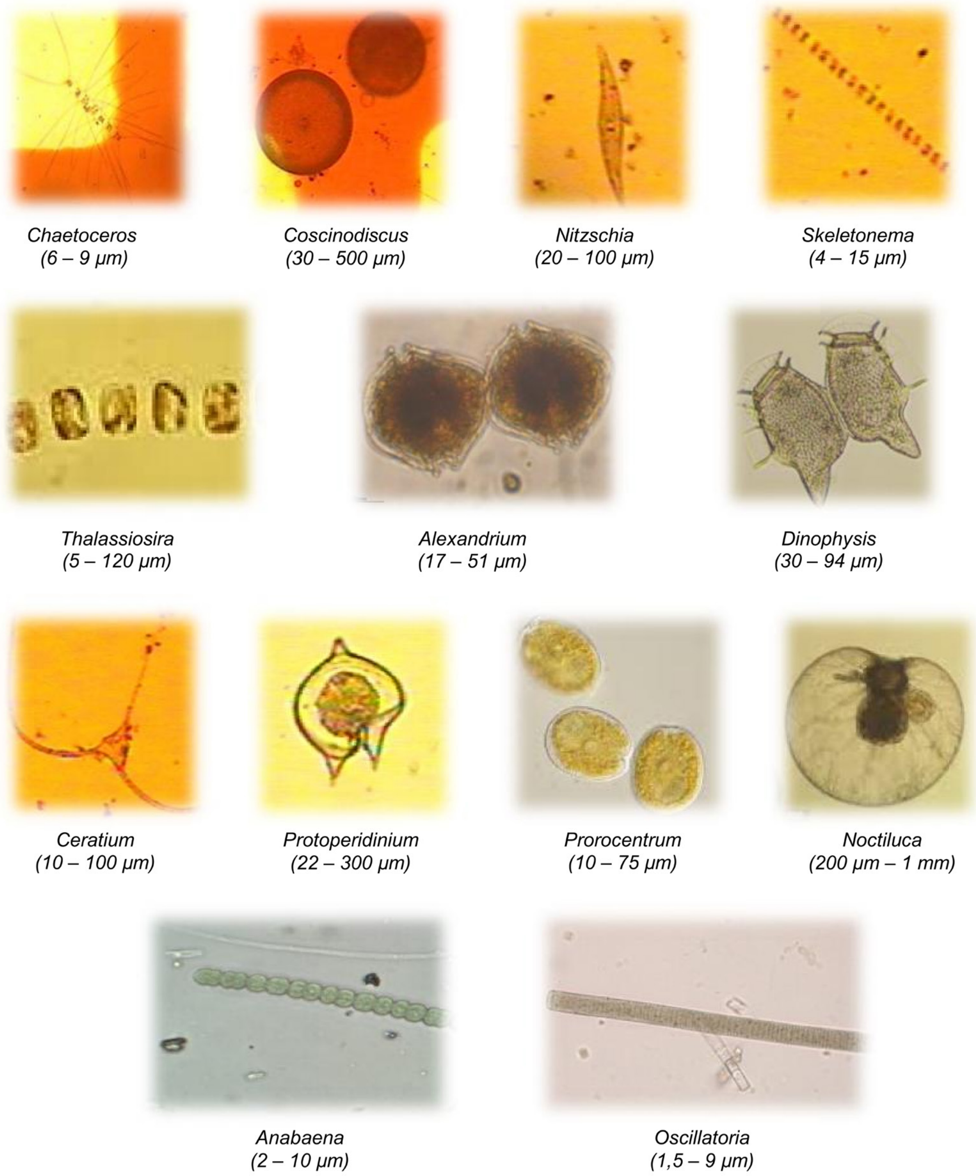

Figure 2. Identified harmful algal that was found in Banyuasin water

HABs. *Chaetoceros, Coscinodiscus, Skeletonema*, *Thalassiosira, Ceratium* dan *Noctiluca* are categorized as intoxic harmfull algae. However, their abundance might cause serious effect to the aquatic ecosystem such as reduction of dissolved oxygen concentration, and clogginess of the fish gill through the formation of sharp cell chain. In contrast, *Nitszchia, Alexandrium, Dinophysis, Protoperidinium Prorocentrum, Anabaena* and *Oscillatoria* are algae with toxic that could harm the human health (Figure 2).

Monitoring result showed that the highest number of potential HABs was occured in June and the highest abundance occured in August, especially *Chaetoceros* and *Skeletonema* (Figure 3).

Both genera are commonly observed in Banyuasin (Aryawati et al., 2005; Isnaini et al., 2012; Surbakti et al., 2011).Sidabutar (2006) showed that in November 2004, blooming of *Skeletonema* and *Noctiluca* has been reported in Jakarta Bay, and recently, algae bloom has been reported especially in Ancol Beach where *Coscinodiscus* spp has been identified (P2O-LIPI, 2015). Both occasion have caused the massive death of fishes. The indication of *Coscinodiscus* bloom in Ancol Beach, its abundance had reached 29.000 sel.L^{-1} during August 2012 (Siagian, 2006; Yuliana, 2012). However, in Hurun Bay, the bloom of *Skeletonema* has occured with the number of cell was than 180.10^6cells.m^{-3} in August. Abundance

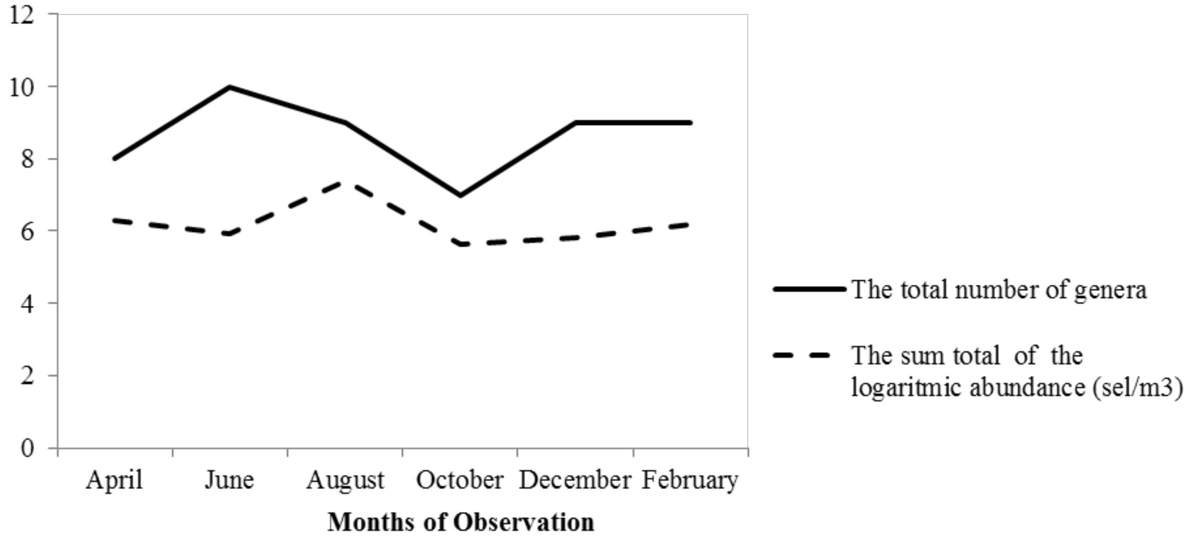

Figure 3. Number of genera and abundance of potential HABs phytoplankton

Table 3. Chemical physics properties of Banyuasin water

Parameters	1st	2nd	3rd	4th	5th	6th
Temperature (^{0}C)	30.05	29.86	28.41	29.30	28.34	28.75
Salinity (PSU)	13.25	24.94	24.55	23.62	17.06	25.10
Turbidity (NTU)	20.31	26.13	36.61	24.24	32.22	32.16
Nitrate (mg.L^{-1})	1.46	1.13	2.18	1.92	1.87	1.37
Phosphate (mg.L^{-1})	0.52	0.69	0.56	0.54	0.57	0.38

of *Skeletonema* in the either month was indicated as the number less than 20.10^{6}cells.m^{-3} (Widiarti, 2000).

Algae blooming has occured many times at Ambon Bay on certain months. Sidabutar (2006) stated that some bloomings were happened in different algae species, abundance and time, i.e: *Trichodesmium erythraeum (Oscillatoria)* with abundance of 3,0.10^{7}cells.m^{-3} on July 1996, *Noctiluca* (3.10^8 cells.m^{-3}, on August 1996), and *Alexandrium* (2,0.10^{9}cells.m^{-3}, on October 1997). Research of Sidabutar (1997) indicated that *Noctiluca* population started increase on July and gain the peak on November. Research by Haumahu (2004) atinner side of Ambon bayon May-July 1994 did not find any *Noctiluca* in water column. Similar research by Haumahu (2005) on Haria Saparua bay,Central Maluku on August-October 2002 also did not find *Noctiluca*.

Environmental Physicochemical Properties

Chemical physics properties of Banyuasin water indicate appropriate conditions for the growth of phytoplankton (Table 3).

In comparation with other regions in Indonesia (Table 4), there are similarities characters among Banyuasin and other waters.

Table 4 informed that nitrateand phosphate content in South Sumatera waters tend to increase year to year. This condition potentially cause *eutrophic*in the future and furthermore can trigger algae blooming of certain species. Pednekar et al. (2012) stated that the abundance of HABs species in coastal waters related to increasing of nutrient content from estuarine as effect of anthropogenic activity. Previous study by Hasani, et al. (2012) also indicated positive significance correlation between nitrateand phosphate content with HABs in some aquaculture area in Lampung Bay. However, based on algae blooming phenomenon which previously occured in Indonesia, and supported by appropriate environmental condition (Table 3).

According to Muawanah et al. (2013), the blooming pattern of *Cochlodinium polykrikoides* at Hurun Bay, Lampung was having characteristic of DIN concentration increased at the beginning which was then followed by a rapid decreased of it due to the consumption by C. polykrikoides characterized by increasing of DIN concen-

Table 4. Chemical physics parameters of some Indonesia waters

Parameters				Location	Source
Tempera-ture (^{0}C)	Salinity (PSU)	Nitrate (mg.L^{-1})	Phosphat (mg.L^{-1})		
25.57-30.7	30-34.1	0.0002-0.0046	0.0003-0.0011	Ambon Bay	Sidabutar (1997)
24.8-31	26-34	0.05-1.60	0.01-1.50	Hurun Bay	Widiarti (2000)
25.27-28.30	31.74-34.42	0.44-4.29	0.30-1.22	Ambon Bay	Haumahu (2004)
26.5-30.1	25.5-31.10	0.015-0.145	0.003-0.054	South Sumatera waters	Aryawati, et al. (2005)
29-33	5-20	0.608-1.487	0.01-0.06	South Sumatera waters	Isnaini, et al. (2012)
30-32	20-27	0.64-2.62	0.13-1.81	Jakarta Bay	Mulyani, et al. (2012)
30.7-30.9	31.10-31.12	1-2.1	0.22-0.31	South Sumatera waters	Isnaini, et al. (2014a)

tration firstly and then decrease very fast due to be used by *C. polykrikoides* for*blooming*. Furthermore, Muawanah et al. (2013) stated that during *C. polykrikoides* blooming, DIN concencentration was ranged 0,016-1,219 mg.L^{-1}and ortho-phosphate concentration was ranged 0,001 - 0,150 mg.L^{-1}. The other environmental parameters were 30-32 psu; 27,9-29,8^0 C; 4,30-5,64 mg.L^{-1};and pH 7,45-7,99 for salinity, temperatur, dissolved xygen, and pH respectively.The study of Widiarti (2000) showed that*Skeletonema* had positive correlation with phosphate, while *Pyrodinium was* more affected by salinity and high nitrat concentration that were usually found near the mangrove area.

Different phenomena of algae blooming from previous studies suggested that the causes of algae bloom were unclear and might be related to many environment factors.

CONCLUSION

The study found *13 species that were identified as Harmful Algal* (*Chaetoceros, Coscinodiscus, Nitzschia, Skeletonema, Thalassiosira, Alexandrium, Ceratium, Dinophysis, Noctiluca, Protoperidinium, Prorocentrum, Anabaena* and *Oscillatoria*), *with 7 of them contain toxin* (*Nitzschia, Alexandrium, Dinophysis, Protoperidinium Prorocentrum, Anabaena* and *Oscillatoria*) in Banyuasin water. Monitoring result showed that the highest number of potential HABs were in June and the highest abundance of algae was in August.

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