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 calculate species 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) occurred in June and the highest abundance occurred 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 bacteria 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 10⁶ cells.m⁻³ for small sized phytoplankton. Harmful Algal Blooms (HABs) could be defined as overgrowth 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 erythraeum. 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, Procentru lima, dia tom Pseudo-nitzschia multiseries, P. Australis, cyanobacteria Anabaena circularis, Nodularia spumigena. The third group is algae that do not harm 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 & Sugestinsih, 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 occurrences of HABs species were related to climate condition that affect aquatic environ-
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 & Elbracht, 2010).

Phytoplankton was observed by using microscope equipped 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**

**Phytoplankton 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 *Bacillariastrium, 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., 2013; Ismunarti, 2013; Thoha & Aryawati, 2014).

*Chaetoceros* was found every month probably due to their high adaptation level. Morphologically, *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 & Sugestiningh, 2000).

**The Possible Occurrence of HABs**

As being described in the previous paragraphs, several phytoplankton categorized as
Table 1. Identified phytoplankton in Banyuasin water

| No | Phytoplankton   | Months | 1st | 2nd | 3rd | 4th | 5th | 6th |
|----|----------------|--------|-----|-----|-----|-----|-----|-----|
| 1  | Amphora        |        | +   | -   | -   | +   | -   | +   |
| 2  | Asterionella   |        | -   | -   | -   | -   | +   | -   |
| 3  | Bacillaria     |        | -   | -   | -   | +   | +   | +   |
| 4  | Bacteriastrum  |        | +   | +   | +   | +   | +   | +   |
| 5  | Chaetoceros    |        | +   | +   | +   | +   | +   | +   |
| 6  | Cosinodiscus   |        | +   | +   | +   | +   | +   | +   |
| 7  | Dictylosolen   |        | +   | -   | +   | -   | -   | -   |
| 8  | Dictyocha      |        | -   | -   | +   | +   | -   | -   |
| 9  | Dytitum        |        | -   | +   | +   | +   | +   | +   |
| 10 | Eucampia       |        | -   | -   | +   | -   | -   | -   |
| 11 | Guinardia      |        | -   | +   | +   | +   | +   | +   |
| 12 | Hemidiscus     |        | -   | +   | +   | +   | +   | -   |
| 13 | Hemiaulus      |        | +   | -   | +   | +   | +   | +   |
| 14 | Lauderia       |        | -   | +   | +   | +   | -   | +   |
| 15 | Leptocylindrus |        | +   | +   | +   | -   | -   | +   |
| 16 | Melioskra      |        | -   | -   | -   | +   | +   | -   |
| 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 |
|----|---------------|------------------------------|-----|-----|-----|-----|-----|-----|
| 1  | *Amphora*     | 708                          | 0   | 0   | 0   | 1.345| 0   | 4.247|
| 2  | *Asterionella*| 0                           | 0   | 0   | 0   | 0    | 21.234| 0   |
| 3  | *Bacillaria*  | 0                           | 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  | *Dictylosolen*| 29.019                      | 0   | 1.415| 0    | 0    | 0   |
| 8  | *Dictyocha*   | 0                           | 0   | 1.415| 1.416| 0    | 0   |
| 9  | *Ditylum*     | 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 | *Melosira*    | 0                           | 0   | 0    | 425  | 21.943| 0   |
| 17 | *Nitzschia*   | 21.587                      | 44.805| 164.545| 12.883| 40.345| 67.236|
| 18 | *Odontella*   | 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|
| 35 | **Chlorophyceae**|                             |     |     |     |     |     |     |
|    | *Staurastrum* | 0                           | 0   | 0    | 0    | 708  | 0   |

Note: genera name with underline mark represent the HABs genera
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, *Nitzschia, 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; Yuli-ana, 2012). However, in Hurun Bay, the bloom of *Skeletonema* has occured with the number of cell was than 180.10⁶ cells.m⁻³ in August. Abundance
Table 3. Chemical physics properties of Banyuasin water

| Parameters     | 1st  | 2nd  | 3rd  | 4th  | 5th  | 6th  |
|----------------|------|------|------|------|------|------|
| Temperature (°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  |

![Graph showing number of genera and abundance of potential HABs phytoplankton](image)

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

Environmental Physicochemical Properties

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

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

Table 4 informed that nitrate and phosphate content in South Sumatera waters tend to increase year to year. This condition potentially cause eutrophication 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 nitrate and phosphate content with HABs in some aquaculture area in Lampung Bay. However, based on algae blooming phenomenon which previously occurred 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               |
|------------------|----------------|----------------------|
| Temperature (°C) | Salinity (PSU) | Nitrate (mg.L⁻¹)     |
| 25.57-30.7       | 30-34.1        | 0.0002-0.0046        |
| 24.8-31          | 26-34          | 0.01-1.60            |
| 25.27-28.3       | 31.74-34.42    | 0.44-4.29            |
| 26.5-30.1        | 25.5-31.10     | 0.015-0.145          |
| 29.33            | 5-20           | 0.608-1.487          |
| 30-32            | 20-27          | 0.64-2.62            |
| 30.7-30.9        | 31.10-31.12    | 1-2.1                |

| Parameters       | Phosphat (mg.L⁻¹) | Location       | Source               |
|------------------|-------------------|----------------|----------------------|
| 0.0003-0.0011    |                   | Ambon Bay      | Sidubutar (1997)     |
| 0.01-1.50        |                   | Hurun Bay      | Widiarti (2000)      |
| 0.30-1.22        |                   | Ambon Bay      | Haumahu (2004)       |
| 0.003-0.054      |                   | South Sumatera waters | Aryawati, et al. (2005) |
| 0.01-0.06        |                   | South Sumatera waters | Isnaini, et al. (2012) |
| 0.13-1.81        |                   | Jakarta Bay    | Mulyani, et al. (2012) |
| 0.22-0.31        |                   | South Sumatera waters | Isnaini, et al. (2014a) |

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 (Chlorella, Coscinodiscus, Nitzschia, Skeletonema, Thalassiosira, Alexandrium, Ceratium, Dinophysis, Noctiluca, Protoperidinium, Prorocentrum, Anabaena and Oscillatoria), with 7 of them contain toxin (Nitzschia, Alexandrium, Dinophys, 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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