Identification of Phytoplankton That Causes Harmful Algae Blooms (Habs) in The Hurun Bay Water

S W Pawhestri¹, R Nurdevita¹, D A Saputri¹, O P Winandari¹
¹Universitas Islam Negeri Raden Intan Lampung
*suciwulanpawhestri@radenintan.ac.id

Abstract. This study aimed to determine the abundance of phytoplankton and determine the type of phytoplankton that has the potential to cause Harmful Algae Blooms (HABs) in the waters of the Hurun Bay, and analyze the water quality in the Hurun Bay with physical, chemical and biological parameters. The results of this study are expected to be a source of information regarding the diversity of phytoplankton and water quality in Hurun Bay so that HABs can be prevented. Phytoplankton sampling was carried out in February 2018 at three observation stations (floating net cages, floating fish cage and docks) with sampling using the plankton net. The results of this study detected 9 genus of potentially dangerous phytoplankton (HABs) namely Chaetoceros (46,097 cells/L), Bacteriastrum (1,011 cells/L), Nitzschia (1,295 cells/L), Pseudo-nitzschia (598 cells/L), Pyrodinium (1,011 cells/L), 624 cells/L), Alexandrium (431 cells/L), Prorocentrum (836 cells/L), Skeletonema (615 cells/L), and Protoperidinium (640 cells/L). Based on the results of the correlation analysis it was concluded that the parameters that have a strong relationship and affect the abundance of phytoplankton (HABs and Non-HABs) are pH (p <0.01) with the strength of a strong and positive relationship.

Keyword: bay water, harmful algal blooms, plankton

1. Introduction

More than 70% of the earth's surface is covered by water[1–3], which is in the form of oceans, rivers, lakes, and so on[4–6]. Water is a habitat for several organisms such as plankton and macrobenthos[7]. Plankton and macrobenthos have an important role in maintaining the balance of the ecosystem as well as being a bio-indicator of water quality in an ecosystem because they can absorb pollutants in water[7–9].

Plankton is a collection of living organisms consisting mostly of microorganisms, which float or hover in water or drift on the surface of aquatic ecosystems[9, 11]. Plankton is often referred to as a bioindicator of water quality[11–13] because plankton has a fairly wide distribution in the aquatic environment, has a long life span, has a good response to environmental changes, and does not move quickly when the environment is contaminated with pollutants. Plankton consists of phytoplankton and zooplankton[6, 11–14].

Phytoplankton in aquatic ecosystems plays a role as a basis for life, which is a contributor to oxygen and organic matter. Phytoplankton has chlorophyll which plays a role in photosynthesis to produce organic matter and oxygen in the water which is used as the basis of a chain in the food cycle at sea. However, certain phytoplankton has a role in reducing the quality of marine waters if the amount is excessive (blooming)[10].

Excessive increase in the phytoplankton population (population explosion/algae bloom) can occur due to favorable environmental conditions[19]. The explosion of the phytoplankton population
followed by the presence of toxic phytoplankton will cause an explosion of dangerous algae population (Harmful Algae Blooms)[19]. Phytoplankton blooming can occur due to natural factors and human factors (anthropogenic effect). Natural factors such as; nutrient circulation in waters, upwelling and downwelling, entry of nutrients carried by river flow, increased temperature (during seasonal changes), and rainfall.

The high population of toxic phytoplankton in water can cause various negative effects on aquatic ecosystems[18, 19], such as the reduction of oxygen in the water which can cause the death of various other aquatic creatures. This is exacerbated by the fact that several types of phytoplankton with a potential for blooming are toxic, such as those from several groups of dinoflagellates, namely Alexandrium sp., Gymnodinium sp., And Dinophysis sp. From the Diatom group Chaetoceros sp. including phytoplankton that destroys the respiratory system and Pseudo-nitzschia sp. including toxic phytoplankton that causes Amnesic Shellfish Poisoning (ASP).

This study aims to inventory and determine the density and distribution of phytoplankton that has the potential to cause Harmful Algae Blooms (HABs) in the waters of the Hurun Bay which is part of Lampung Bay and analyze the water quality in the Hurun Bay with physical, chemical and biological parameters.

2. Method
This research was conducted in February 2018. Sampling was carried out in the waters of the Hurun Bay, Lampung, while the measurement of physical and chemical parameters was carried out at the Lampung Marine Fisheries Aquaculture Laboratory located on Jalan Yos Sudarso, Padang Cermin, Pesawaran Regency, Lampung, and specifically for COD measurements carried out at the Lampung State Polytechnic Water Analysis Laboratory.

This research method is a descriptive case study while determining the sampling location used the Purposive Random Sampling method at three observation stations (stations A, B, and C) with the following design. Sampling locations are determined based on differences in cultivation activities found at each location. The samples were taken from three stations and water samples were taken to identify the biological indicator (a), BOD (b), and COD (c)[21].

The plankton sampling method used is the vertical towing method. Samples were taken by filtration technique, namely by taking 100 ml of water sample then the water sample was filtered using a 30µ plankton net and the results were put into a 250 ml sample bottle that had been labeled. This vertical plankton removal method is intended to determine the distribution of plankton in various layers of water. A bucket at the end of the plankton net is used to collect them. Buckets cannot hold too much water. This container is usually in the form of a tube that is easily removed from the tube. 4% formalin will be dropped into a sample bottle at the fixation stage (preservation) for further identification in the laboratory.

The diversity index (H’) is calculated using the Shannon-Wiener equation formula, then the uniformity index (E) is calculated using the Evenness equation, while for the dominance index (D) the dominance index formula is used from Simpson.

\[
H' = -\sum_{i=1}^{s} Pi \ln Pi
\]

\[
E = H'/H_{maks}
\]

\[
D = \sum_{i=1}^{s} \left( \frac{ni}{N} \right)^{2}
\]
3. Results and Discussion

The results of identification based on the type of phytoplankton enumeration found in the sample during the study detected that there were 65 genera included in 51 families. Among the 65 genera of phytoplankton found in the waters of the Hurun Bay, the species with the highest number of cell abundances is Chaetoceros sp. Algae are said to be blooming when the algal concentration ratio reaches thousands to 10^6 individuals per liter.

The results showed that phytoplankton species in the waters of Hurun Bay which had the potential to cause HABs were detected as much as 85.5% of the total abundance of phytoplankton, including those from the red tide maker and toxin producer group and some were non-toxic but their body structure could be dangerous if it entered the body of the organism other. Phytoplankton that has the potential to cause Harmful Algae Blooms (HABs) were identified as many as 9 genera, including Chaetoceros, Nitzschia, Bacteriastum, Prorocentrum, Protoperidinium, Pyrodinium, Skeletonema, Pseudo-nitzschia, and Alexandrium; derived from the family Chaetocerotaceae, Bacillariaceae, Prorocentraceae, Protoperidiniaceae, Goniodomataceae, and Skeletonemataceae as can be seen on Table 1.

| No | Famil | Genus      | Spesies            | N     |
|----|-------|------------|--------------------|-------|
| 1  | Chaetocerotaceae | Bacteriastium | Bacteriastumsp. | 1011  |
|    |       | Chaetoceros | Chaetocerossp. | 42.111|
|    |       |             | Chaetocerossocialis | 3.986 |
| 2  | Bacillariaceae | Nitzschia   | Nitzschiasp. | 1.295 |
|    |       | Pseudo-nitzschia | Pseudo-nitzschiasp. | 598   |
| 3  | Goniodomataceae | Pyrodinium  | Pyrodiniumbahamense | 624   |
| 4  | Prorocentraceae | Alexandrium | Alexandriums. | 431   |
|    |       | Prorocentrum | Prorocentrumsp. | 836   |
| 5  | Skeletonemataceae | Skeletonema | Skeletonenasp. | 615   |
| 6  | Protoperidiniaceae | Protoperidinium | Protoperidiniumsp. | 640   |

3.1 Chaetocerotaceae

Chaetoceros sp. and Chaetocerossocialis come from the same family as Bacteriastum sp. namely the Chaetocerotaceae family, which is the most dominant diatom found in marine waters. This is evidenced in the results of research in which the three species dominate the composition of phytoplankton at each station. The high adaptability by Chaetoceros is seen from the morphology of the body that has many branches, branching life, and large body size, allowing this species to live even in polluted aquatic environments. Phytoplankton is not toxic to humans but can physically disrupt the respiratory system of fish and invertebrates, especially if the individual density is relatively high.

Chaetoceros can cause hemolytic effects and infect biota if the abundance exceeds 5000 individuals/L. In research in the waters of Hurun Bay, Chaetoceros was found in all stations in each sampling with a total abundance of 46,069 individuals/L. Algae are said to be blooming when the algal concentration ratio reaches thousands to 106 individuals/L. Thus, Chaetoceros can be said to be blooming but has not reached the dangerous stage of Harmful Algae Blooms (HABs). This needs to be watched out because it can endanger the marine ecosystem if it enters the food chain. Whereas Bacteriastum is also found in all stations with a total abundance of 1,011 individuals/L which shows that Bacteriastum also has the potential to cause Harmful Algae Blooms (HABs).
3.2 Bacillariaceae
In research in the waters of the Hurun Bay, Nitzschia sp. and Pseudo-nitzschia sp. found in all stations in each sampling with a total density of 1,295 individuals/L and 598 individuals/L respectively. Algae are said to be blooming when the algal concentration ratio reaches thousands to 106 individuals/L. Although not blooming, but Nitzschia sp. and Pseudo-nitzschia sp. still has the potential to cause Harmful Algae Blooms (HABs). This needs to be watched out because it can endanger humans because of the poisons they have.

3.3 Prorocentraeaceae
Prorocentrum sp., Which comes from the family Prorocentraeaceae, was found in all research stations and was identified to cause hypoxia and anoxia. Toxin from Prorocentrum sp. known as ciguatoxin/maitotoxin results in acute digestive disorders with symptoms of diarrhea, vomiting, stomach cramps, excessive sweating, and cold. Prorocentrum sp. potential to cause Red Tide when its abundance in waters explodes along with Ceratium sp. In research in the waters of the Hurun Bay, Prorocentrum sp. found in all stations in each sampling with a total density of 836 individuals/L. Algae are said to be blooming when the algal concentration ratio reaches thousands to 106 individuals/L. Although not blooming, but Prorocentrum sp. potentially causing Harmful Algae Blooms (HABs). This needs to be watched out because it can endanger aquatic biota to humans.

3.4 Protoperidiniun
Protoperidinium sp., Derived from the Protoperidiniunaceae family, can produce Azaspiracids which are similar to DSP toxins that can cause nausea in patients within 3 to 5 days. In research in the waters of the Hurun Bay, Protoperidinium sp. found in all stations in each sampling with a total density of 640 individuals/L. Algae are said to be blooming when the algal concentration ratio reaches thousands to 106 individuals/L. Although not blooming, but Protoperidinium sp. potentially causing Harmful Algae Blooms (HABs). This needs to be watched out because there are several cases of poisoning caused by this type of algae.

3.5 Goniodomataeaceae
Pyrodiniumbahamense and Alexandrium sp. comes from the family Goniodomataeaceae. In this research in the waters of the Hurun Bay, Pyrodiniumbahamense and Alexandrium sp. found in all stations with a total density of 624 individuals/L and 431 individuals/L respectively. Algae are said to be blooming when the algal concentration ratio reaches thousands to 106 individuals/L. Although not blooming, but Pyrodiniumbahamense and Alexandrium sp. potentially causing Harmful Algae Blooms (HABs). This needs to be watched out because these two algae are found in waters throughout Indonesia and cause many cases of fish death and poisoning in humans.

3.6 Skeletonemataeaceae
Skeletonema sp., Which comes from the family Skeletonemataeaceae, is a dangerous phytoplankton that causes hypoxia and anoxia when consumed. If this species blooms, it can clog the respiratory apparatus and cause mass death in aquatic biota. In this research in the waters of the Hurun Bay, Skeletonema sp. found in all stations in each sampling with a total density of 615 individuals/L. Algae are said to be blooming when the algal concentration ratio reaches thousands to 106 individuals/L. Although not blooming, but Skeletonema sp. potentially causing Harmful Algae Blooms (HABs). This needs to be watched out for because Skeletonema sp. can cause mass death in fish.

Several other studies support the results of this study that the seven families are indeed abundant in marine waters in Indonesia. The results of previous studies indicate that the families that dominate the waters of Lampung Bay are the Bacillariaceae, Goniodomataeaceae, and Prorocentraeaceae families. From the toxin producer group, Nitzschia sp. and Pseudo-nitzschia sp. is phytoplankton that has the potential to cause Harmful Algae Blooms (HABs) which are most commonly found in Lampung Bay.
See on Figure 1, it can be seen that the lowest abundance of phytoplankton is found in station 1 with a percentage of 26.92% and then followed by an abundance of phytoplankton in the station 2 with a percentage of 32.20%. The highest abundance of phytoplankton is found at station 3 with a percentage of 40.88% of the total abundance of phytoplankton in all stations. One of the causes of high abundance at the pier station is the amount of waste from transportation equipment (ships) which triggers the growth of several species of phytoplankton.

The factor that influences the abundance of phytoplankton station 3 is the existence of human activities from the mainland which provides waste in the form of organic matter and then enters the sea. When connecting with the concentration of nutrients, especially nitrate (NO3) which indeed tends to be higher at the dock station. The effect of this activity decreases as the location is farther from the land. This can be seen in the station farthest from the mainland, which is the KJA station with the lowest abundance of phytoplankton.

To analyze various physical and chemical parameters that influence the presence of HABs, a correlation test is conducted between the overall abundance of phytoplankton (HABs and Non-HABs) with various parameters such as nitrate, nitrite, phosphate, pH, COD, DO, BOD, temperature, salinity, brightness, and depth. Based on the Spearman correlation analysis results found that the parameters that have a strong relationship and affect the abundance of phytoplankton (HABs and Non-HABs) are pH (p <0.01) with very strong and positive relationship strength. Besides pH, although it did not reach a significant number, phosphate had a relatively strong correlation but was negative. Other parameters such as nitrate, nitrite, COD, DO, BOD, temperature, salinity, brightness, and depth tend not to show a real relationship.

4. Conclusion
An abundance of phytoplankton species that live in the waters of the Hurun Bay was detected by 65 genera belonging to 51 families. Types of potentially dangerous phytoplankton (HABs) in the waters of the Hurun Bay, there are 9 genera from 6 families, namely: Chaetoceros and Bacteriastum from the family Chaetoceraceae, Nitzschia and Pseudo-nitzschia from the Bacillariaceae family,
Prorocentrum from the family Prorocentraceae, Protoperidiniasis, Protoperidini, Skeletonema from the Skeletonemataceae family, Pyrodinium and Alexandrium from the Goniodomataceae family.

References

[1] A. Moreira, G. Krieger, I. Hajnsek, and K. Papathanassiou2015Tandem-L: A Highly Innovative Bistatic SAR Mission for Global Observation of Dynamic Processes on the Earth’s Surface,” IEEE Geosci. Remote Sens. 3 2
[2] J.-F. Pekel, A. Cottam, N. Gorelick, and A. S. Belward 2016 High-resolution Mapping of Global Surface Water and Its Long-term Changes Nature 540 418–422
[3] C. Kidd et al. 2019 So, How Much of the Earth’s Surface Is Covered by Rain Gauges Bull. Am. Meteorol. Soc. 11
[4] T. Nakayama 2017 Development of An Advanced Eco-hydrologic and Biogeochemical Coupling Model Aimed at Clarifying The Missing Role of Inland Water in The Global Biogeochemical Cycle J. Geophys. Res. Biogeosciences 122 4
[5] S. S. Viana, L. F. M. Vieira, M. A. M. Vieira, J. A. M. Nacif, and A. B. Vieira 2016 Survey on The Design of Underwater Sensor Nodes Des. Autom. Embed. Syst. 20 3
[6] S. Pawhestri, J. Hidayat, and S. P. Putro 2014 Assesment of Water Quality Using Macrobenthos as Bioindicator and Its Application on Abundance- Biomass Comparison (ABC) Curves Int. J. Sci. Eng. 8 2
[7] A. Smebye et al. 2016 Biochar amendment to soil changes dissolved organic matter content and composition Chemosphere 142 100–105
[8] J. R. Griffiths, M. Kadin, F. J. A. Nascimento, and T. Tamelander 2017 The Importance of Benthic–pelagic Coupling for Marine Ecosystem Functioning in A Changing World Glob. Chang. Biol. 23 6
[9] K. Ortega-Cisneros, U. M. Scharler, and A. K. Whitfield 2016 Carbon and nitrogen system dynamics in three small South African estuaries, with particular emphasis on the influence of seasons, river flow and mouth state Mar. Ecol. Prog. Ser. 557
[10] B. Li, X. Li, T. J. Bouma, and L. M. Soissons 2017 Analysis of Macrobenthic Assemblages and Ecological Health of Yellow River Delta, China, using AMBI & M-AMBI Assessment Method Mar. Pollut. Bull. 119 2
[11] B. Ghanbaria and J. F. Gómez-Aguilar 2018 Modeling The Dynamics of Nutrient–Phytoplankton–Zooplankton System with Variable-Order Fractional Derivatives Chaos, Solitons & Fractals 116
[12] Y. Pan, S. Yan, R. Li, Y. Hu, and X. Chang 2017 Lethal/Sublethal Responses of Daphnia Magna to Acute Norfloxacin Contamination and Changes in Phytoplankton-zooplankton Interactions Induced by This Antibiotic Sci. Reports 7.
[13] M. Colina, D. Calliari, C. Carballo, and C. Kruk 2016 A trait-based approach to summarize zooplankton–phytoplankton interactions in freshwaters Hydrobiologia. 767 1
[14] C. E. H. Kissman, C. E. Williamson, K. C. Rose, and J. E. Saros 2016 Nutrients Associated with Terrestrial Dissolved Organic Matter Drive Changes in Zooplankton: Phytoplankton Biomass Ratios in an Alpine Lake Freshw. Biol. 62 1
[15] L. G. Rudstam et al.2017Nutrients, Phytoplankton, Zooplankton, and Macrobenithos(United States of America: USGS Science for Changing World)
[16] M. Javidi and B. Ahmad 2015 Dynamic Analysis of Time Fractional Order Phytoplankton–toxic Phytoplankton–zooplankton System Ecol. Modell. 318 8–18
[17] C. Le Quere, E. T. Buitenhuis, R. Moriarty, and S. Alvain 2016 Role of Zooplankton Dynamics for Southern Ocean Phytoplankton Biomass and Global Biogeochemical Cycles CentAUR Cent. Arch. Univ. Read. 13 14
[18] S. J. Taipale, A. W. E. Galloway, S. L. Aalto, K. K. Kahlilainen, U. Strandberg, and P. Kankaala 2016 Terrestrial Carbohydrates Support Freshwater Zooplankton during Phytoplankton Deficiency Sci. Reports 6
[19] D. M. Anderson, J. M. Burkholder, W. P. Cochlan, P. M. Gilbert, C. J. Gobler, and C. A. Heil 2008 *Harmful Algal Blooms and Eutrophication: Examining Linkages from Selected Coastal Region of the United States, Harmful Algae* (USA: NIH Public Access)

[20] L. Prosniera, M. Loreau, and F. D. Hulot 2015 Modeling The Direct and Indirect Effects of Copper on Phytoplankton–Zooplankton Interactions *Aquat. Toxicol.* 162 73–81

[21] F. Fachrul and M. Ferianita 2012 *Metode Sampling Bioekologi* (Jakarta: Bumi Aksara)