The presence of harmful algae in the coastal waters of Bintan Island, Riau Islands

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ABSTRACT

Environmental mitigation measures are being undertaken as a proactive approach to prevent the adverse consequences associated with Harmful Algal Blooms (HABs). Presently, there is a lack of comprehensive information regarding the occurrence of HABs in the waters surrounding Bintan Island, and routine monitoring to assess the potential for eutrophication is absent. This research should begin by gathering information about potential sources that contribute to the emergence of HABs, the specific types of algae with the capacity to trigger HABs. The primary objective of this study is to identify the harmful algae species present in the coastal waters of Bintan Island. The research was conducted in August 2023, with the sampling process taking place at four specific locations within the coastal waters of Bintan Island. These sampling stations were selected deliberately to capture the varying activities predominant in each respective area. The microalgae found consisted of four groups, namely Bacillariophyta, Cyanophyta, Dinophyta, and Chlorophyta. Bacillariophyta is a group of microalgae with the highest abundance proportion at all observation stations. Harmful Algae found in the coastal waters of Bintan Island generally come from the Dinophyta group of the types Ceratium sp., Peridinium sp., Prorocentrum sp., and Dinophysius sp. Harmful microalgae from the Dinophyta group were found at all research stations, with the highest proportion of abundance at Station 2 (6%) and the lowest at Station 3 (1%). The difference in these findings is thought to be due to the dynamics of the hydrosanographic parameters of the waters, especially nutrient concentrations.

ARTICLE INFO

Keywords:
Bintan
Ceratium
Dinophyta
Harmful
Microalgae

Introduction

The dynamics of organic matter concentration in coastal waters, existing in particulate and dissolved forms, have been explored in a study by Isada et al. (2021). Within aquatic environments, organic materials undergo decomposition by microbial action, resulting in the conversion of these substances into inorganic nutrients. In typical circumstances, this process serves to enhance the aquatic primary productivity. Nevertheless, the excessive conditions can lead to an upsurge in the population of phytoplankton and algae, as noted by Sulateri et al. (2022). Prior investigations into algae within the waters surrounding Bintan Island have primarily focused on diversity assessments and the documentation of phytoplankton species. Syafriani and Apriadi (2017) carried out research within the Sei Canal Waters in Tanjungpinang City, revealing that these waters exhibited a significant dominance of the Dinophyta, particularly Ceratium sp. This observation suggests the presence of ecological pressures within the waters. Consistent with other research findings, it has been reported that Diatoms (Bacillariophyta) generally prevail in the seawaters surrounding Bintan Island. This aligns with the results of Ayu et al. (2017) research, which identified Bacillariophyta as the predominant microalgae in the coastal waters of Bintan.

The occurrence of algal blooms, specifically Trichodesmium sp. (Cyanophyta) and Paralia sp. (Bacillariophyta), in Lagoi Waters in mid-February 2018 serves as an indicator of the possible emergence of Harmful Algal Blooms (HABs) in Bintan Waters, as highlighted in the study by Syakti et al. (2019). Through observations conducted to assess the potential for HABs in Bintan Island waters during
July-August 2018, it was determined that the waters of Kampung Baru Lagoi had the highest proportion of algal abundance compared to other locations, as reported by Syakti et al. (2019).

The precise cause of the blooming phenomenon in Lagoi Waters remains uncertain. Typically, blooms are triggered by an increase in nutrient levels in the water, a phenomenon known as eutrophication. It has been suggested that imbalances in the ratio of nitrogen (N) to phosphorus (P) nutrient concentrations in the water can also lead to the emergence of algal blooms, as discussed by Xu et al. (2015). The occurrence of these blooms is influenced by three primary factors: the presence of nutrients, light availability, and water stagnation. These factors, in turn, are affected by weather conditions and the hydro-oceanographic conditions within the potentially affected areas. Various studies have reported specific nutrient patterns in different parts of Bintan Island. The southern region of the island shows phosphate enrichment, the northern part exhibits both phosphate and nitrate enrichment, while the eastern part experiences relatively lower nutrient levels, as documented by Meirinawati and Muchtar (2017), Azizah (2017), and Lestari et al. (2014). Additionally, the quality of water in Bintan has been found to vary based on anthropogenic pressures, which can impact the potential for algal blooms, as indicated by Dharmawan et al. (2015) and Fachri et al. (2015). It is important to note that hydro-oceanographic dynamics play a pivotal role in shaping the overall trophic level of these waters.

Aquatic trophic level serves as a reflection of the primary productivity within an aquatic ecosystem. It is closely intertwined with water quality as it profoundly influences the existence of aquatic organisms, as emphasized by Zulfiah and Aisah (2013). This connection is established through factors such as nutrient levels, oxygen concentrations, and phytoplankton abundance, all of which are pivotal indicators of water trophic level. Understanding the condition of water trophic level forms the foundation for the effective management of biological resources in aquatic environments. Inadequate water trophic level can impede the thriving of aquatic life, as highlighted by Fitra et al. (2012). Additionally, excessively hypertrophic can actually have detrimental consequences on the sustainability of the aquatic ecosystem, including the potential for a population explosion of Harmful Algal Blooms (HABs).

Environmental mitigation measures are being undertaken as a proactive approach to prevent the adverse consequences associated with HABs. Presently, there is a lack of comprehensive information regarding the occurrence of HABs in the waters surrounding Bintan Island, and routine monitoring to assess the potential for eutrophication is absent. Consequently, there is a pressing need for a comprehensive investigation. This research should begin by gathering information about potential sources that contribute to the emergence of HABs, the specific types of algae with the capacity to trigger HABs, and the potential for eutrophication in Bintan Island waters. These efforts are aimed at mitigating the occurrence of HABs. The primary objective of this study is to identify the harmful algae species present in the coastal waters of Bintan Island.

Materials and Methods
Location and time of research
The research was conducted in August 2023, with the sampling process taking place at four specific locations within the coastal waters of Bintan Island. These sampling stations were selected deliberately to capture the varying activities predominant in each respective area. Detailed maps illustrating the sampling locations and the specific stations are provided in Figure 1, and a comprehensive breakdown of these stations is available in Table 1.

![Figure 1. Research Sampling Map](image)

Table 1. Description of Observation Sites

<table>
<thead>
<tr>
<th>Station</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Located in Sebong Pereh Waters, the northern region of Bintan Island, this area is renowned as a popular tourist destination</td>
</tr>
<tr>
<td>2</td>
<td>Situated in the eastern part of Bintan Island, this area serves as both a tourism destination and a dedicated location for seagrass conservation efforts</td>
</tr>
<tr>
<td>3</td>
<td>Found within the waters of Tanjungpinang City, this area is situated in the south-southwest region of Bintan Island. It is</td>
</tr>
</tbody>
</table>

Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Volume 13, Number 1, Page 32-38
characterized by a blend of domestic, urban, and shipping industry activities that dominate the area. Positioned in the northwestern sector of Bintan Island, this area is primarily characterized by industrial activities that dominate the region.

Sampling Method
At each station, hydro oceanographic parameters were measured, and phytoplankton samples were taken at 8 randomly determined sampling points by software QGIS 3.22.1. Hydrooceanographic parameters measured in situ are pH, temperature, DO (using a multimeter), salinity (using a refractometer), TDS, and conductivity measured using (using TDS meter), transparency (using Secchi disc), turbidity (using a turbidimeter), current speed (using current drudge), and light intensity (using a Lux meter). Reference in measuring hydro-oceanographic parameters based on APHA (2012). While measurement methods for hydrooceanographic parameters adhered to the standards outlined in APHA (2012).

In the laboratory analysis, we focused on examining the types and abundance of phytoplankton/microalgae. To collect 120 L water samples for microalgae analysis, we employed a plankton net at euphotic depths, following the static method. Microalgae enumeration was carried out using the Sedgewick Rafter Counting Chamber, employing the census method outlined in APHA (2012). The identification of algae types was based on references from Yamaji (1979) and Davis (1955). The calculation of phytoplankton abundance was conducted following the guidelines provided in APHA (2012).

Results
Aquatic Environmental Parameters
Generally, the physical and chemical parameters of the waters at each station met the requirements for phytoplankton/microalgae life (Table 1).

Abundance and Proportion of Microalgae
The abundance of phytoplankton was relatively the same at Stations 1 (375,076 cells/m$^3$), 2 (328,133 cells/m$^3$), and 4 (471,521 cells/m$^3$) (Figure 2). Station 3 has the highest phytoplankton abundance of 2,517,461 cells/m$^3$. This is thought to be related to the input of organic and inorganic materials from the land around these waters. Heavy activity around waters can trigger an increase in phytoplankton abundance. Station 3, which is located on the coast of Tanjungpinang City (the southern part of Bintan Island), is directly influenced by domestic activities (densely populated settlements and markets), urban areas, and the shipping industry.

### Table 1. Water parameters condition

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Station 1</th>
<th>Station 2</th>
<th>Station 3</th>
<th>Station 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>29.7±0.95</td>
<td>29.4±0.13</td>
<td>29.8±0.32</td>
<td>29.9±0.22</td>
</tr>
<tr>
<td>Transparency (m)</td>
<td>2.26±1.14</td>
<td>2.60±0.84</td>
<td>1.33±0.27</td>
<td>2.65±0.59</td>
</tr>
<tr>
<td>Depth (m)</td>
<td>3.09±3.76</td>
<td>5.64±8.51</td>
<td>16.7±4.25</td>
<td>23.5±4.25</td>
</tr>
<tr>
<td>Water velocity (m/s)</td>
<td>0.10±0.07</td>
<td>0.10±0.15</td>
<td>0.11±0.02</td>
<td>0.13±0.10</td>
</tr>
<tr>
<td>Light Intensity (Lux)</td>
<td>20000±0</td>
<td>16,084±4,576</td>
<td>17,644±7,763</td>
<td>19,658±744</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>0.18±0.13</td>
<td>0.66±0.54</td>
<td>2.45±1.98</td>
<td>0.67±0.61</td>
</tr>
<tr>
<td>DO (mg/L)</td>
<td>6.79±0.58</td>
<td>7.55±0.82</td>
<td>7.07±1.10</td>
<td>6.91±0.46</td>
</tr>
<tr>
<td>pH</td>
<td>8.32±0.07</td>
<td>8.33±0.05</td>
<td>8.01±0.30</td>
<td>8.15±0.08</td>
</tr>
<tr>
<td>Salinity (ppt)</td>
<td>32±4</td>
<td>32±1</td>
<td>26±1</td>
<td>27±2</td>
</tr>
<tr>
<td>TDS (mg/L)</td>
<td>26,291±519</td>
<td>29,444±203</td>
<td>21,156±296</td>
<td>22,096±1,361</td>
</tr>
<tr>
<td>Conductivity (µhmhos/cm)</td>
<td>52,620±1108</td>
<td>58,980±474</td>
<td>42,324±535</td>
<td>4,384±2,751</td>
</tr>
</tbody>
</table>
Harmful Algae

Based on the findings of this study, microalgae in the area were categorized into four groups: Bacillariophyta, Cyanophyta, Dinophyta, and Chlorophyta. Among these groups, Bacillariophyta displayed the highest abundance across all observation stations (Figure 3).

Harmful microalgae, often referred to as Harmful Algae, have been identified in the coastal waters of Bintan Island, and they predominantly belong to the Dinophyta group. Figure 4 likely provides an overview of some of the specific types of harmful microalgae that were encountered and identified in this study.

Figure 2. Total abundance of microalgae in coastal waters of Bintan Island

Figure 3. Proportion of microalgae abundance in the coastal waters of Bintan Island

Discussion

Aquatic Environmental Parameters

The existence of phytoplankton as primary producers in the waters is highly dependent on the quality of the environment in the area. It also depends on several factors, such as depth, transparency, temperature, water velocity, salinity, pH, dissolved oxygen (DO), and nutrients (Wiyarsih et al., 2019; Akbar et al., 2023).

Temperature stands out as one of the most frequently monitored physical parameters, and within aquatic ecosystems, water temperature assumes a crucial role in shaping the existence of organisms. This is due to its profound influence on their survival, as it actively regulates the conditions within bodies of water.

Water temperature, in turn, is subject to variations driven by seasonal changes, weather patterns, diurnal fluctuations, and the depth of the water itself. It's worth noting that the temperature within aquatic environments significantly impacts the presence and dynamics of various organisms, with a particular emphasis on phytoplankton, which are highly attuned to specific temperature ranges. Harmful dinoflagellate algae grow optimally in the temperature range of 25-30.6 °C (Nasution et al., 2021).

To maintain the well-being of marine biota, it is essential to adhere to established standards, such as those outlined in the Seawater Quality Standards in Government Regulation of the Republic of
Indonesia Number 22 of 2021, specifically in Appendix VIII, which prescribes a temperature quality range of 28-30°C conducive to biota growth. Notably, all monitoring stations were found to be in compliance with this standard. Nasution et al. (2021) explained that Dinoflagellate abundance has a positive correlation with temperature. This is in accordance with the statement by Grigorszky et al. (2003) that temperature is the most important factor in controlling the emergence of species from the Dinophyta group.

The pH level of water is a measure of its acidity or alkalinity, determined by the concentration of hydrogen ions present. According to the Sea Water Quality Standards outlined in Republic of Indonesia Government Regulation Number 22 of 2021 Appendix VIII, designed for the well-being of marine biota, the recommended pH quality standard falls within the range of 7 to 8.5. It’s noteworthy that the pH values recorded at all monitoring stations met this standard. Harmful dinoflagellate algae could grow in the pH range of 5.53-8.80 and has negatively correlated with pH (Nasution et al., 2021). In essence, this optimal pH range promotes the nutrient cycling necessary for the growth and sustenance of marine life.

Dissolved oxygen (DO) in water primarily results from the photosynthesis process carried out by phytoplankton and other aquatic producers. During periods without sunlight, respiration rates surpass photosynthesis rates in these aquatic environments. This condition is especially true during algae blooming events, as stated by Dewi et al. (2018) that the potential for HABs blooming can cause a decrease in DO concentration.

Additionally, it’s important to note that dissolved oxygen levels are influenced by water temperature and salinity, with oxygen content varying as these parameters change. The Seawater Quality Standards established in Republic of Indonesia Government Regulation Number 22 of 2021 Appendix VIII, specifically designed to promote the well-being of marine biota, set a quality standard range for dissolved oxygen (DO) of greater than 5 mg/l. Encouragingly, the recorded DO concentrations at all monitoring stations meet or exceed this standard, indicating favorable conditions for aquatic life in these waters. Nasution et al. (2021) explained that dissolved oxygen has a positive correlation with Dinoflagellate abundance.

Salinity is a measure of the salt content dissolved in one kilogram of seawater. It is primarily influenced by air temperature. High water temperatures lead to increased evaporation, resulting in higher salinity values in the water. The level of salinity in water plays a significant role in determining the presence and distribution of plankton within aquatic ecosystems. Nasution et al. (2021) explained that salinity has a negatively correlated with Dinoflagellate abundance.

The impact of salinity on phytoplankton is closely linked to the specific salinity range that is optimal for their growth. Phytoplankton tend to thrive in salinity conditions ranging from 15 to 32 ppt. This range provides the ideal environment for their development and productivity. In summary, salinity levels in seawater are influenced by factors such as temperature and evaporation. These salinity levels, in turn, have a direct impact on the presence and growth of phytoplankton and other organisms in aquatic ecosystems, with specific salinity ranges favoring their development.

The turbidity levels recorded at the four observation stations remain relatively low, falling within the range of 0.18 to 2.45 Nephelometric Turbidity Units (NTU). These turbidity values are in compliance with the water quality standard outlined in Government Regulation of the Republic of Indonesia Number 22 of 2021, which sets a turbidity limit of 5 NTU. Station 2, characterized by lower transparency, recorded the highest turbidity value among the stations. Dinoflagellate abundance has negatively correlated with salinity (Nasution et al., 2021).

In the study locations, the current velocity is relatively uniform across all stations and falls within the category of slow currents. This consistency in current velocity suggests a relatively stable hydrodynamic environment in the studied areas. In summary, the observed turbidity levels meet the established water quality standards, and the water currents in the study locations are classified as slow, indicating a consistent and calm hydrodynamic condition in these areas. Current velocity plays an important role in the distribution of plankton in the water column (Espinasse et al., 2023).

Total Dissolved Solids (TDS) refer to the total concentration of dissolved materials in water. These materials include various chemical compounds and other substances commonly present in aquatic environments. When measuring TDS, a high concentration indicates that the water contains a significant quantity of dissolved substances. Importantly, high TDS levels can impact not only the water’s salinity but also its conductivity, and the relationship between TDS, salinity, and conductivity is typically proportional. According to Rui et al. (2013), the abundance of phytoplankton was increased as TDS increased during the logarithmic
phase, and Cyanophyta more adaptability to TDS increment.

**Abundance and Proportion of Microalgae**

Various coastal activities contribute to the introduction of organic matter into water bodies, and this influx has a substantial impact on water quality, as noted by Irawati (2014). In aquatic environments, organic materials are subject to decomposition by microorganisms, resulting in the production of inorganic nutrients. This decomposition process is most effective under aerobic conditions, requiring a certain level of oxygen concentration. The nutrients generated through the breakdown of organic matter are subsequently utilized by primary producers in coastal waters, particularly phytoplankton, during the photosynthesis process.

Notably, specific diatom types dominated at each station: *Thallassionema* sp. at Stations 3 and 4, *Chaetoceros* sp. at Station 2, and *Coccosiopsis* sp. at Station 1. These results align with the findings of Syakti et al. (2019), who also identified Bacillariophyta as the most abundant group in the coastal waters of Bintan Island. Bacillariophyta is a class of phytoplankton frequently encountered in various aquatic habitats, especially in coastal and marine waters. Given its adaptability, resilience in extreme conditions, high reproductive capacity, and widespread distribution, the Bacillariophyta group of diatoms can serve as a valuable biological indicator for assessing the health of aquatic environments, particularly those that are relatively unpolluted. Additionally, the prevalence of Bacillariophyta in aquatic environments can be attributed to the remarkable adaptability of this diatom group. Bacillariophyta exhibits a capacity to thrive in diverse environmental conditions, including the ability to endure extreme circumstances. Moreover, these diatoms possess a notable reproductive potential and are widely distributed, earning them the classification of being cosmopolitan.

Figure 3 provides valuable insights into the presence of harmful microalgae belonging to the Dinophyta group at all research stations. Station 2 exhibited the highest proportion of Dinophyta abundance at 6%, while Station 3 recorded the lowest abundance at 1%. Comparing these findings to the research conducted by Syakti et al. (2019) reveals notable differences in the proportion of Dinophyta abundance in the study area. Syakti et al. (2019) reported that the highest proportion of harmful algae abundance was detected in the northern and southwestern regions of Bintan Island, which correspond to Stations 1 and 4 in this study. Conversely, the eastern part of Bintan Island, represented by Station 2, had a very low proportion of harmful algae abundance. This disparity in findings is believed to be attributed to the complex dynamics of hydrographic parameters in the water, particularly variations in nutrient concentrations. Isada et al. (2021) have emphasized the significance of spatial and temporal dynamics in nutrient distribution within aquatic environments. These dynamics are closely linked to the abundance and distribution of phytoplankton, including harmful microalgae. Therefore, differences in nutrient concentrations and other hydrographic factors in various parts of the study area likely contributed to the variation in harmful microalgae abundance observed in different locations. In summary, the presence and abundance of harmful microalgae from the Dinophyta group vary across research stations, likely due to differences in water hydrographic parameters, especially nutrient concentrations, as highlighted in the research by Isada et al. (2021). Understanding these spatial and temporal dynamics is crucial for assessing and managing the presence of harmful microalgae in aquatic ecosystems.

**Conclusion**

The microalgae found consisted of four groups, namely Bacillariophyta, Cyanophyta, Dinophyta, and Chlorophyta. Bacillariophyta is a group of microalgae with the highest abundance proportion at all observation stations. Harmful Algae found in the coastal waters of Bintan Island generally come from the Dinophyta group of the types *Ceratium* sp., *Peridinium* sp., *Prorocentrum* sp., and *Dinophysis* sp. Harmful microalgae from the Dinophyta group were found at all research stations, with the highest proportion of abundance at Station 2 (6%) and the lowest at Station 3 (1%). The difference in these findings is thought to be due to the dynamics of the hydrosanographic parameters of the waters, especially nutrient concentrations.

**Acknowledgments**

This research was funded by Directorate General of Higher Education, Research, and Technology, Ministry of Education, Culture, Research, and Technology, Republic of Indonesia with contract No.133/E5/PG.02.00.PL. Special thanks are dedicated to Timbul, Niko, Rani, and Widya who participated during this study from Department of Aquatic Resources Management, Raja Ali Haji Maritime University.
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How to cite this paper: