

Abundance and Species Diversity of Phytoplankton in the Waters of the Air Hitam Strait, Meranti Islands

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ABSTRACT

The Air Hitam Strait, located in Meranti Islands Regency, Indonesia, is an estuarine ecosystem influenced by the mixing of seawater and freshwater, making it a potentially productive habitat for phytoplankton communities. This study aimed to analyze phytoplankton abundance and diversity and their relationship with water quality in the study area. The study was conducted in December 2025 using a survey method, and phytoplankton samples were collected horizontally at three sampling stations representing port, mangrove, and residential areas. The observed parameters included species composition, abundance, diversity index (H'), and water quality characteristics. The results showed that the phytoplankton community consisted of 18 species from four classes: Bacillariophyceae, Dinophyceae, Chlorophyceae, and Euglenophyceae. Phytoplankton abundance ranged from 8,109 to 11,798 ind/L, with the highest abundance recorded at Station III (residential area). One-way ANOVA indicated significant differences in phytoplankton abundance among sampling stations ($p < 0.05$). The diversity index (H') ranged from 3.4783 to 3.9057 and was classified as high, indicating a relatively stable phytoplankton community. In conclusion, environmental conditions and anthropogenic activities influenced phytoplankton abundance and diversity in the Air Hitam Strait, while the overall water conditions remained favorable for sustaining phytoplankton communities.

Keywords: Phytoplankton, Abundance, Diversity, Water quality, Selat Air Hitam

1. INTRODUCTION

The Air Hitam Strait, located in Tebing Tinggi District, Meranti Islands Regency, is an estuarine ecosystem influenced by the mixing of seawater and freshwater. These conditions result in salinity fluctuations and provide suitable habitats for various aquatic organisms, including phytoplankton. In addition, water currents, tidal dynamics, and nutrient inputs from terrestrial sources contribute to this area's high primary productivity potential.

Phytoplankton are microscopic autotrophic organisms that function as primary producers in aquatic ecosystems. They play a vital role as the main energy source in aquatic food webs and contribute significantly to biogeochemical cycles in aquatic environments. Moreover, phytoplankton abundance and diversity are widely used as indicators of the ecological status and trophic condition of aquatic ecosystems (Firdaus & Wijayati, 2019).

Phytoplankton communities in aquatic ecosystems generally comprise several major groups, including Bacillariophyceae, Dinophyceae, Chlorophyceae, and

Cyanophyceae. Among these groups, Bacillariophyceae (diatoms) typically dominate coastal and estuarine waters because they adapt well to nutrient-rich environments. In contrast, Dinophyceae tend to flourish under more stable environmental conditions with high light availability (Tambaru et al., 2022). Changes in phytoplankton community structure may reflect environmental variations resulting from both natural processes and anthropogenic activities (Fynnisa et al., 2024).

Various physicochemical factors influence phytoplankton abundance and diversity, including temperature, salinity, pH, dissolved oxygen, water currents, and nutrient availability. Stable environmental conditions promote balanced phytoplankton communities, whereas changes in these parameters can alter community structure and affect aquatic productivity (Mala et al., 2024).

In recent years, human activities near the Air Hitam Strait, including port operations, coastal settlements, and fisheries activities, have increased considerably. These activities may increase inputs of organic matter and domestic

waste into the aquatic environment, potentially affecting water quality and phytoplankton communities (Rahmah et al., 2022). Previous studies in the Meranti Islands region have also demonstrated that environmental conditions and nutrient availability play important roles in regulating plankton dynamics in aquatic ecosystems (Kamaruddin, 2018).

Despite its high ecological significance, information on phytoplankton abundance, relative abundance, and diversity in the Air Hitam Strait remains limited. Therefore, this study examined phytoplankton species composition, abundance, relative abundance, and diversity, as well as their relationship with water quality conditions in the Air Hitam Strait. The findings are expected to provide valuable scientific information on the ecological status of the aquatic environment, particularly regarding primary productivity and environmental quality, and to support the sustainable management and conservation of coastal ecosystems in Meranti Islands Regency.

2. RESEARCH METHOD

Time and Place

This study was conducted from October 2025 to March 2026. We collected samples in December 2025 in the waters of the Air Hitam Strait, Tebing Tinggi District, Meranti Islands Regency, at three sampling stations (Figure 1). Station I was located in the port area, Station II in the mangrove area, and Station III in the residential area. Water quality analyses and phytoplankton identification were conducted at the Marine Biology Laboratory, Department of Marine Science, Faculty of Fisheries and Marine Sciences, Universitas Riau.



Figure 1. Map of the study area

Method

This study employed a survey method combined with laboratory analyses. Field

observations and sample collection were conducted directly at the study site without applying any experimental treatments. Sampling stations were selected using a purposive sampling approach based on the characteristics of the surrounding environment, namely the port area, mangrove area, and residential area. At each station, we collected phytoplankton samples in five replicates using horizontal sampling during low tide.

Procedures

We measured water quality parameters, including temperature, salinity, pH, current velocity, transparency, and dissolved oxygen (DO), in situ. We analyzed nitrate, phosphate, silicate, and CO₂ concentrations ex situ in the laboratory using spectrophotometric methods.

Phytoplankton samples were collected using a 10-L bucket and filtered through a 25-µm plankton net with ten successive filtrations. The concentrated samples were transferred into 125-mL sample bottles and preserved with 4% Lugol's solution. Sampling was conducted from morning to midday.

Phytoplankton identification was performed using a binocular microscope, following the identification guides of Yamaji (1976); Davis (1995). The collected data were analyzed to determine phytoplankton species composition, abundance, and diversity indices at each sampling station.

Phytoplankton Identification

Phytoplankton identification was performed using an Olympus CX21 binocular microscope. A drop of the phytoplankton sample was placed on a microscope slide, covered with a coverslip, and observed in 12 fields of view at 100× magnification. Phytoplankton species were identified based on the identification guides of Yamaji (1976); Davis (1995).

Phytoplankton Abundance

Phytoplankton abundance was calculated using the following formula (APHA, 1995):

$$N = \frac{T}{L} \times \frac{P}{p} \times \frac{V}{v} \times \frac{1}{w}$$

Description:

- N = Phytoplankton abundance (ind/L)
- T = Cover glass area (625 mm²)
- L = Field of view area (1.306 mm²)
- P = Number of phytoplankton counted.
- p = Number of observed fields of view

- V = Volume of filtered sample (125 mL)
 v = Volume under the cover glass (0.06 mL)
 W = Volume of filtered water (100 L)

Relative Abundance (RA)

Relative abundance was calculated using the formula of Odum & Barrett (1971):

$$KR = \frac{ni}{N} \times 100\%$$

Description:

- KR = Relative abundance (%)
 ni = Number of individuals of the i-th species
 N = Total number of individuals

Phytoplankton Diversity

The phytoplankton diversity index was calculated using the Shannon-Wiener diversity index (1963):

$$H' = - \sum_{i=1}^s pi \log_2 pi$$

Description:

- H' = Diversity index
 pi = Relative proportion of the i-th species
 ni = Number of individuals of the i-th species
 N = Total number of individuals
 S = Total number of species

The diversity index was classified according to these criteria: $H' < 1$: low diversity; $1 \leq H' \leq 3$: moderate diversity; $H' > 3$: high diversity, indicating a relatively stable community

Data Analysis

The data were presented in tables and graphs and analyzed descriptively. Differences in phytoplankton abundance among sampling stations were assessed using one-way analysis of variance (one-way ANOVA).

3. RESULT AND DISCUSSION

Description of the Study Area

Meranti Islands Regency, located in Riau Province, Indonesia, possesses extensive coastal waters, including the Air Hitam Strait. The strait serves as an important inter-island transportation route and supports various socioeconomic activities of coastal communities. Geographically, the Air Hitam Strait is located between 102°12'00"-103°10'00"E and 0°42'30"-

1°28'00" N. The total area of Meranti Islands Regency is approximately 3,707.84 km².

The waters of the Air Hitam Strait are classified as shallow to moderately deep and are strongly influenced by tidal fluctuations, water currents, and freshwater inputs from adjacent land areas. These conditions contribute a substantial supply of organic matter and sediments to the aquatic environment, influencing primary productivity. The study area is dominated by mangrove ecosystems, which play an important role in supplying natural nutrients through the decomposition of mangrove litter. In addition, anthropogenic activities such as port operations, marine transportation, capture fisheries, and coastal settlements contribute organic matter and nutrients to the aquatic environment (Rahmah et al., 2022).

Water Quality Parameters

Water quality measurements indicated that environmental conditions in the Air Hitam Strait were generally favorable for phytoplankton growth. The measured parameters included temperature, salinity, pH, current velocity, transparency, dissolved oxygen (DO), carbon dioxide (CO₂), nitrate, phosphate, and silicate.

Table 1. Water quality parameters

Parameter	Station I	Station II	Station III
Temperature (°C)	29	30	31
Salinity (ppt)	25	26	25
pH	7.93	7.83	7.84
Current velocity (m/s)	0.20	0.15	0.27
Transparency (cm)	1.73	1.79	1.52
DO (mg/L)	4.49	4.44	4.75
Carbon Dioxide (mg/L)	8	5	7
Nitrate (mg/L)	0.0745	0.0479	0.1433
Phosphate (mg/L)	0.0973	0.1017	0.1044
Silicate (mg/L)	0.8916	1.1984	0.9410

Based on Table 1, water temperature ranged from 29 to 31°C, which is within the optimal range for tropical phytoplankton growth. Tambaru et al. (2022) reported that the optimum temperature for phytoplankton growth generally ranges from 25 to 32°C. Salinity

values ranged from 25 to 26 ppt, indicating the influence of seawater–freshwater mixing. Such conditions are characteristic of estuarine and coastal waters receiving freshwater inputs from rivers.

pH values ranged from 7.83 to 7.93, indicating neutral to slightly alkaline conditions favorable for phytoplankton metabolic activity. According to Zainuri et al. (2023), the optimum pH range for aquatic organisms is between 6.5 and 8.5. The concentrations of nitrate, phosphate, and silicate suggest relatively high

nutrient availability in the study area. These nutrients play an essential role in supporting phytoplankton growth, particularly members of Bacillariophyceae, which require silicate to form their frustules (Astriana et al., 2022).

Identified Phytoplankton Composition

Based on the observations and identification results, a total of 18 phytoplankton species were recorded across the sampling stations.

Table 2. Classification of phytoplankton found in the Air Hitam Strait waters

Class	Order	Family	Species
Bacillariophyceae	Coscinodiscales	Coscinodiscaceae	<i>Coscinodiscus</i> sp.
	Fragilariales	Fragilariaceae	<i>Synedra ulna</i>
		Fragilariaceae	<i>Ulnaria ulna</i>
		Rhabdonemataceae	<i>Rhabdonema adriaticum</i>
	Naviculales	Meridionaceae	<i>Meridion circulare</i>
		Amphoraceae	<i>Amphora</i> sp.
		Pleurosigmataceae	<i>Gyrosigma balticum</i>
		Pleurosigmataceae	<i>Pleurosigma rigidum</i>
		Pinnulariaceae	<i>Pinnularia</i> sp.
		Naviculaceae	<i>Navicula</i> sp.
		Leptocylindraceae	<i>Leptocylindrus</i> sp.
	Isthmiales	Isthmiaceae	<i>Isthmia</i> sp.
	Bacillariales	Bacillariaceae	<i>Nitzschia</i> sp.
	Surirellales	Surirellaceae	<i>Surirella spiralis</i>
	Aulacoseirales	Aulacoseiraceae	<i>Aulacoseira granulata</i>
Dinophyceae	Prorocentrales	Prorocentraceae	<i>Prorocentrum</i> sp.
Chlorophyceae	Sphaeropleales	Hydrodictyaceae	<i>Tetradron</i> sp.
Euglenophyceae	Euglenales	Euglenaceae	<i>Euglena</i> sp.

Based on Table 2, phytoplankton identification in the waters of the Air Hitam Strait revealed the presence of 18 species belonging to four classes: Bacillariophyceae, Dinophyceae, Chlorophyceae, and Euglenophyceae. Among these groups, Bacillariophyceae was the most dominant, comprising 15 species. The dominance of Bacillariophyceae suggests that the waters of the Air Hitam Strait are relatively fertile and rich in inorganic nutrients, particularly nitrate, phosphate, and silicate. Diatoms thrive in nutrient-rich coastal waters with adequate light, which supports their growth and proliferation (Tambaru et al., 2022).

Phytoplankton Abundance

Phytoplankton abundance is an important parameter for assessing the primary productivity of aquatic ecosystems. As primary producers in

aquatic food webs, phytoplankton abundance is strongly influenced by environmental factors, particularly nutrient availability, light availability, water currents, and anthropogenic activities in the surrounding area. According to Estin et al. (2025), high phytoplankton abundance indicates favorable conditions for photosynthesis and reflects aquatic ecosystems' ability to support biological productivity. Furthermore, phytoplankton are widely used as water-quality indicators because they respond rapidly to environmental changes (Alviyanti et al., 2025).

Based on Figure 2, phytoplankton abundance varied among sampling stations in the Air Hitam Strait. The highest abundance was recorded at Station III (11,798 ind/L), followed by Station II (8,641 ind/L), while the lowest abundance was observed at Station I (8,109 ind/L). These differences suggest that

environmental conditions at each station influenced phytoplankton abundance.

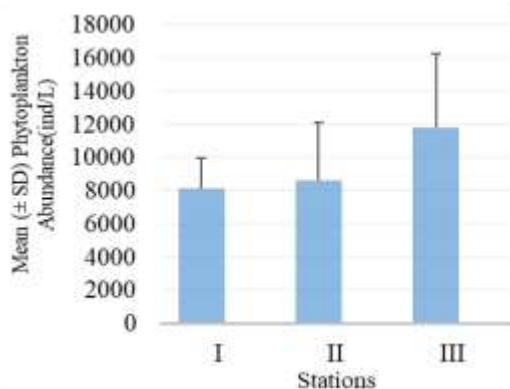


Figure 2. Phytoplankton abundance

The high phytoplankton abundance at Station III was likely associated with elevated nutrient inputs from domestic activities, including household waste and organic runoff from residential areas. These inputs increase nutrient availability, particularly nitrate and phosphate, which are essential for phytoplankton growth. Wijaya et al. (2022) reported that increased nitrate concentrations in coastal waters are generally accompanied by higher phytoplankton biomass. The occurrence of *Euglena* sp. at this station further suggests elevated organic matter inputs, as this species is commonly regarded as an indicator of eutrophic conditions (Hertika et al., 2021).

In contrast, the lower phytoplankton abundance at station I may be attributed to intensive shipping activities, which increase water movement, turbulence, and sediment resuspension. Such conditions can limit phytoplankton accumulation and growth. According to Hidayati et al. (2024), highly dynamic aquatic environments may inhibit phytoplankton development because water currents readily transport cells.

Station II exhibited an intermediate level of phytoplankton abundance. This condition may relate to inputs of organic matter and nutrients from mangrove litter decomposition. Alongi (2021) reported that mangrove ecosystems function as nutrient traps that enhance water fertility and support primary productivity. The one-way ANOVA revealed significant differences in phytoplankton abundance among sampling stations. Post hoc LSD analysis indicated that Station III differed significantly from Stations I and II, whereas no significant difference was observed between Stations I and II. These findings suggest that

variations in environmental conditions, nutrient availability, and anthropogenic activities significantly influence phytoplankton abundance in the Air Hitam Strait.

Phytoplankton community structure can also be evaluated through relative abundance, which represents each species' proportional contribution to the total phytoplankton population.

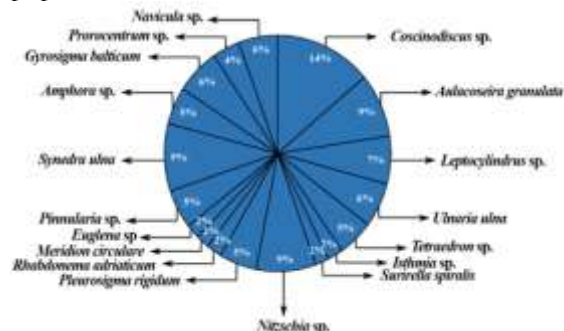


Figure 3. Relative abundance of phytoplankton species

Based on Figure 3, the phytoplankton community in the Air Hitam Strait was dominated by *Coscinodiscus* sp., which accounted for 14% of the total relative abundance. *Aulacoseira granulata*, *Synedra ulna*, and *Nitzschia* sp. followed, each contributing 9%.

The high relative abundance of *Coscinodiscus* sp. may reflect its strong adaptability to environmental variation, particularly changes in salinity and nutrient availability. According to Astriana et al. (2022), *Coscinodiscus* sp. is a diatom that thrives in nutrient-rich coastal waters. In contrast, species such as *Isthmia* sp., *Surirella spiralis*, and *Euglena* sp. exhibited low relative abundances, each accounting for only 2% of the total phytoplankton community, indicating a more restricted distribution.

The observed differences in relative abundance reflect the dominance of certain species within the phytoplankton community. Rahmah et al. (2022) reported that diatom dominance in coastal waters is generally associated with stable environmental conditions and adequate nutrient availability, particularly nitrate, phosphate, and silicate.

Phytoplankton Diversity

Table 3 presents the phytoplankton diversity index at each sampling station in the Air Hitam Strait.

Table 3. Phytoplankton diversity index

Station	Diversity Index (H')	Category
I	3.4783	High
II	3.9057	High
III	3.6165	High

Based on Table 3, the phytoplankton diversity index (H') at all sampling stations in the Air Hitam Strait was categorized as high. The highest diversity index was recorded at Station II, whereas the lowest value was observed at Station I. These results indicate that the phytoplankton community in the Air Hitam Strait is relatively stable and that the aquatic environment is capable of supporting a wide variety of phytoplankton species. According to Odum (1971), an H' value greater than 3 indicates high diversity and a relatively stable ecosystem.

The high diversity index observed at Station II may be attributed to the mangrove ecosystem, which provides a more stable habitat, lower current velocity, and a balanced nutrient supply derived from mangrove litter decomposition. These conditions promote the growth of diverse phytoplankton species without strong dominance by a particular species. Alongi (2021) reported that mangrove ecosystems function as sources of organic matter and nutrient traps, thereby enhancing water fertility and primary productivity.

In contrast, the lower diversity index at station I may reflect intensive shipping and vessel movements, which create more dynamic environmental conditions. Stronger currents, turbulence, and increased turbidity from sediment resuspension may limit the growth of phytoplankton species sensitive to environmental disturbances. Consequently, only a few tolerant species may dominate the community, resulting in lower species evenness compared to the other stations (Mandeno &

Kasim, 2025).

Furthermore, the high phytoplankton diversity observed in the Air Hitam Strait suggests that the overall environmental conditions remain favorable for phytoplankton growth. The availability of nutrients such as nitrate, phosphate, and silicate, together with suitable physicochemical conditions, supports the growth of numerous phytoplankton species. Nevertheless, the dominance of *Coscinodiscus* sp indicates that the community structure is not completely even. This may reflect mild environmental pressure associated with anthropogenic activities, particularly in residential and port areas (Alviyanti et al., 2025)

4. CONCLUSION

Based on the results of this study conducted in the waters of the Air Hitam Strait, Meranti Islands Regency, a total of 18 phytoplankton species belonging to four classes were identified, namely Bacillariophyceae, Dinophyceae, Chlorophyceae, and Euglenophyceae. Bacillariophyceae was the dominant class, comprising 15 species. Phytoplankton abundance ranged from 8,109 to 11,798 ind/L, with the highest abundance recorded at Station III and the lowest at Station I. Variations in phytoplankton abundance among stations indicate that environmental conditions and nutrient availability play important roles in shaping phytoplankton distribution in the Air Hitam Strait. One-way ANOVA revealed significant differences in phytoplankton abundance among sampling stations. The phytoplankton diversity index (H') ranged from 3.4783 to 3.9057 and was classified as high, indicating a highly diverse and relatively stable phytoplankton community. Overall, the environmental conditions of the Air Hitam Strait remain favorable for phytoplankton growth and development.

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