Community Structure of Epiphytic Diatoms on Seagrass Leaves *Thalassia hemprichii* in Cindakir Beach Kabung Bay, West Sumatra

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ABSTRACT

Indonesia is known for its high natural resource diversity, both on land and in its waters. This research aims to determine the types and abundance of epiphytic diatoms on Thalassia hemprichii seagrass leaves at each station, analyze differences in abundance between stations, and analyze the diversity, dominance, and uniformity indices of epiphytic diatom species on *Thalassia hemprichii* seagrass leaves in the waters of Cindakir Beach, Kabung Bay, West Sumatra. This research was conducted in March 2025 in the waters of Cindakir Beach, Kabung Bay, West Sumatra, and the identification and analysis of epiphytic diatoms were carried out at the Marine Biology Laboratory of the Faculty of Fisheries and Marine, Universitas Riau. The method used was a survey. Based on the research results, the abundance of epiphytic diatoms ranged from 1,287- 6,648 ind/cm², the diversity index (H') ranged from 0.9254 -2.2010 (moderate category), the dominance index (C) ranged from 0.2364 - 0.6566, with the dominant species at Station I, and the species evenness index (E) ranged from 0.5845 - 0.9855, indicating that the species evenness of diatoms in the waters of Cindakir Beach is relatively stable. The identification identified 14 epiphytic diatom species: *Nitzschia* sp., *Cymbella* sp., *Cocconeis* sp., *Flagilaria* sp., *Meridion* sp., *Licmophora* sp., *Gyrosigma* sp., *Navicula* sp., *Pleurosigma* sp., *Pinnularia* sp., *Synedra* sp., *Rhizosolenia* sp., *Surirella* sp., and *Amphora* sp. The most frequently found species with the highest abundance were *Rhizosolenia* sp. and *Nitzschia* sp.

Keywords: Epiphytic diatoms, Community structure, Seagrass leaves

1. INTRODUCTION

Indonesia is known for its high natural resource diversity, both on land and in its waters. With three-quarters of its territory covered by water, Indonesia has complex coastal and marine ecosystems in which living and non-living components interact functionally. One of the ecosystems commonly found in most of Indonesia's coastal and marine waters is the seagrass ecosystem. To date, 24 species of seagrass have been recorded in the Indo-Pacific region, of which 14 are still found in Indonesian waters (Tana & Kailola, 2024). This highlights the importance of seagrass ecosystems in Indonesia's biodiversity.

The highly supportive aquatic environment in coastal areas allows seaweed ecosystems to develop and grow optimally (Devayani et al., 2019). Seaweed is highly adaptable to salinity levels and has a distinctive structure, including rhizomes, leaves, and true roots (Kawaroe et al., 2016). Seagrass beds, as the primary ecosystem in coastal areas, are known as seagrass beds. Seagrass beds have various functions, including sediment trapping, oxygen production, and coastal protection by dampening currents and waves. Biologically, seagrass beds serve as habitats for various marine species, including as spawning, nursery, and feeding grounds. Various marine organisms, such as crustaceans, molluscs, and fish, live and reproduce in seagrass ecosystems. As a result, seagrass beds significantly contribute to the productivity of coastal ecosystems, supporting the survival of various marine organisms.

Seagrass beds are highly productive ecosystems, where high productivity stems not only from seagrass vegetation but also from algae and autotrophic organisms attached to seagrass known as epiphytic diatoms. Epiphytic diatoms, as microalgae attached to seagrass leaves, play a crucial role in marine ecosystems. Seaweed and epiphytic diatoms together serve as an important nutrient source for various organisms, thereby supporting the continuity of the food chain within aquatic ecosystems (Samosir et al., 2022). Additionally, epiphytic diatoms serve as biological indicators of pollution in marine environments, enabling water-quality assessment based on their presence and condition (Herlina et al., 2018; Akbar et al., 2020).

Calm water conditions allow epiphytic diatoms to attach effectively to seaweed surfaces. The presence of epiphytic diatoms benefits seaweed by protecting it from ultraviolet rays. Additionally, epiphytic diatoms serve as natural food for higher aquatic organisms, such as zooplankton and various fish species, within the seaweed ecosystem (Devayani et al., 2019). However, environmental factors such as physical-chemical water conditions can influence water quality and the structure of the epiphytic diatom community, indicating that diatoms have certain tolerance limits to environmental changes (Ginting et al., 2024).

This study aims to determine the types and abundances of epiphytic diatoms on *Thalassia hemprichii* seaweed leaves at each station, analyze differences in abundance between stations, and examine the diversity, dominance, and uniformity of epiphytic diatom species on *T. hemprichii* seaweed leaves in the waters of Cindakir Beach, Kabung Bay, West Sumatra. The method used in this study was a survey, with observations and sampling conducted in the waters of Cindakir Beach.

2. RESEARCH METHOD

Time and Place

This research was conducted in March 2025 in the waters off Cindakir Beach, Kabung Bay, Padang City, West Sumatra Province (Figure 1). Sample analysis was conducted at the Marine Biology Laboratory and the Marine Chemistry Laboratory of the Department of Marine Science, Faculty of Fisheries and Marine Sciences, Universitas Riau.

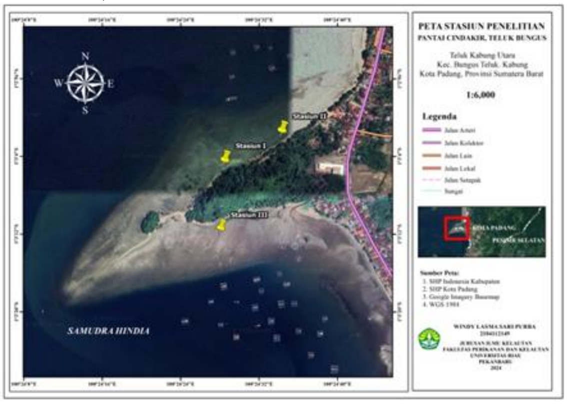

Figure 1. Map of research location

Method

The sampling stations were determined using purposive sampling, which selects stations based on seagrass characteristics, in this case, seagrass density. The selection of sampling locations was determined after conducting field observations.

Procedures

Determination of Sample Collection Stations

Each station has different characteristics. The criteria for dividing stations in the waters of Cindakir Beach are as follows: Station I: Located in an area with dense seagrass beds, ± 10 m from the coastline and a water depth of ± 50 cm. Distance to Station II is ± 200 m.

Station II: Located in an area with moderate seagrass density, ±10 m from the shoreline, with a water depth of ±70 cm. The distance to Station III is ± 250 m. Station III: Located in a seagrass bed with low density, ±10 m from the shoreline and at a water depth of ± 50 cm. Seagrass density can be calculated using the following equation:

$$Ki = Ni/A$$

Explanation:

Ki	=	Density of species 1 (trees/m^2)
Ni	=	Total number of individuals of species 1 (trees)
A	=	Total area of sampling (m^2)

Sampling and Observation of Epiphytic Diatoms

Sampling was conducted between 10.30 and 15.00 WIB, during low tide. The sampling locations consisted of three stations, each with three transects spaced 50 m apart, and each transect with three plots measuring 1 m x 1 m, spaced 5 m apart.

Diatom sampling was conducted by selecting one seagrass stand and cutting two undamaged seagrass leaves from it. Diatom sampling was conducted by scraping two (2) parts of the seagrass leaves (upper and lower surfaces) with a total scraping area of 40 cm². Scraping was performed on both seagrass leaves using a brush, which were then sprayed with a distilled water solution and collected on a tray. The sample was placed in a 50 mL sample bottle, added with 4% Lugol's solution, labelled as a marker, and stored in an ice box for subsequent transport to the laboratory for identification.

Diatom samples were observed in the laboratory by taking a dropperful from the bottle after thorough mixing. One drop was placed on an object glass, covered with a cover glass, and observed under a binocular microscope at 10x10 magnification using the 12-field method with three repetitions, performed on all samples. Each diatom obtained is identified using the identification books by APHA in Arifin et al. (2018)

Data Processing

Epiphytic Diatom Abundance

The abundance of epiphytic diatoms can be calculated using a modified Lackey Drop Microtransecting Method, referring to (APHA in Arifin et al., 2018), namely:

$$N = 3Oi/Op \times Vr/3Vo \times 1/A \times n/3p$$

Where:

N	:	Number of diatoms per unit area (ind/cm^2)
Oi	:	Area of the cover glass (484 mm^2)
Op	:	Area of the binocular microscope field of view (1,306 mm^2)
Vr	:	Volume of solution in the sample bottle (50 mL)
Vo	:	Volume of 1 drop of sample (0.06 mL)
A	:	Area of the scraping field (1x10=10) x 2 (2) = 40 cm^2)
N	:	Number of epiphytic diatoms collected (ind)
P	:	number of fields of view (12 strips)

Diversity Index (H')

The diversity index of epiphytic diatoms was calculated using the Shannon-Wiener diversity index (H'), referring to (Odum in Arifin et al., 2018) as follows:

$$H' = \sum_{i=1}^{s} pi\ Log2\ pi$$

Explanation:

H'	=	Diversity index
Pi	=	Proportion of the number of individuals to – i relative to the total number of individuals (ni/N)
Log2 pi	=	Log pi x 3.3219
S	=	Number of species

The diversity index criteria are divided into 3 categories: H' < 1: Low species diversity; 1≤ H' ≤ 3: Moderate species diversity; H' > 3: High species diversity.

Dominance Index (C)

To calculate the dominance of diatom species in a water body, the Simpson dominance index (C) is used, referring to (Odum in Arifin et al., 2018), namely:

$$C = \sum_{i=1}^{s} \left(\frac{ni}{N}\right)^2$$

Where:

C	:	Dominance Index
Ni	:	Number of individuals per species/unit
N	:	Total number of individuals from all species
S	:	Number of species/unit

The criterion is that if the dominance index value is close to 0, then there is no dominant species, and a high diversity index accompanies this. Conversely, if the dominance index approaches 1, a single species dominates the population (community structure is unstable due to ecological pressure or stress).

Species Uniformity Index (E)

The species uniformity index can be calculated using the Pilou formula (Krebs in Arifin et al., 2018), which is:

$$E = H'/Log_2S$$

Where:

E	=	Species uniformity index
H'	=	Diversity index
Log2 S	=	Log S x 3.3219
S	=	Number of species or types

With the following criteria: 0<E≤ 0.5 : Low species uniformity (suppressed); 0.5 < E ≤ 0.75 : Moderate species uniformity (unstable); 0.75 < E ≤ 1: High species uniformity (stable)

Data Analysis

The data obtained from sampling were presented in tables and graphs for further descriptive discussion. The diversity, dominance, and uniformity of epiphytic diatom species were calculated using Microsoft Excel 2010 software. To determine differences in abundance between stations, a one-way ANOVA was performed in SPSS.

3. RESULT AND DISCUSSION

Classification and Composition of Epiphytic Diatoms

Based on the results of identifying epiphytic diatoms on *T. hemprichii* seagrass leaves in the waters of Cindakir Beach, 10 orders, 12 families, and 14 species were found. The classification of epiphytic diatoms is shown in Table 1.

The composition of epiphytic diatoms on *T. hemprichii* leaves at stations I, II, and III can be seen in Table 2. The highest composition of epiphytic diatoms was found at station I, with 11 species, followed by station II with 10 species, and station III with 8 species.

Table 1. Classification of epiphytic diatoms on *T.hemprichii* seagrass leaves

Class	Order	Family	Species
Bacillariophyceae	Bacillariales	Bacillariaceae	*Nitzschia* sp.
	Cymbellales	Cymbellaceae	*Cymbella* sp.
	Cocconeidales	Cocconeidaceae	*Cocconeis* sp.
	Fragilariales	Flagilariaceae	*Flagilaria* sp.
			Meridion sp.
	Licmophorales	Licmophoraceae	*Licmophora* sp.
	Naviculales	Pleurosigmataceae	*Gyrosigma* sp.
		Naviculaceae	*Navicula* sp.
			Pleurosigma sp.
		Pinnulariaceae	*Pinnularia* sp.
	Pennales	Fragilariaceae	*Synedra* sp.
	Rhizosoleniales	Rhizosoleniaceae	*Rhizosolenia* sp.
	Surirellales	Surirellaceae	*Surirella* sp.
	Thalassiophysales	Catenulaceae	*Amphora* sp.

Table 2. Composition of epiphytic diatoms found at each station

No	Species	Station I	Station II	Station III
1	*Nitzschia* sp.	+	+	+
2	*Cymbella* sp.	-	+	+
3	*Cocconeis* sp.	+	-	+
4	*Flagilaria* sp.	+	-	-
5	*Meridion* sp.	-	+	-
6	*Licmophora* sp.	-	-	+
7	*Gyrosigma* sp.	+	+	+
8	*Navicula* sp.	+	+	-
9	*Pleurosigma* sp.	+	+	+
10	*Pinnularia* sp.	+	+	-
11	*Synedra* sp.	+	+	-
12	*Rhizosolenia* sp.	+	+	+
13	*Surirella* sp.	+	+	+
14	*Amphora* sp.	+	-	-
	Total	11	10	8

Based on Table 2, there are differences in the diatom species found at each station. The epiphytic diatom species found at all three stations include *Nitzschia* sp., *Gyrosigma* sp., *Pleurosigma* sp., *Rhizosolenia* sp., and *Surirella* sp. In comparison, the epiphytic diatom species found at two stations include *Cymbella* sp., *Pinnularia* sp., *Navicula* sp., *Synedra* sp., *Cocconeis* sp., and epiphytic diatoms found only at one station, namely *Flagilaria* sp., *Meridion* sp., *Licmophora* sp., and *Amphora* sp. Overall, the highest diatom abundance at the three stations was observed in the species *Nitzschia* sp. and *Rhizosolenia* sp.

The most commonly found species, *Rhizosolenia* sp., belongs to the centric diatoms. This diatom belongs to a genus found throughout tropical waters (*circumtropical*) and has adapted to warm temperatures, making this species commonly encountered (Devayani et al., 2019). *Nitzschia* sp. is one of the most common diatom species in estuaries and coastal waters. This is because the area has abundant nutrients. According to Tarigas et al. (2020), diatoms are highly adaptable to aquatic environments, exhibit high tolerance to environmental changes, and can be found in a wide range of habitats.

Gyrosigma sp. is a cosmopolitan diatom with a wide distribution and high tolerance to environmental changes (Dionfriski et al., 2021). This is consistent with Sachlan's view in Dionfriski et al. (2021) that *Nitzschia* sp., *Gyrosigma* sp., and *Pleurosigma* sp. are genera with cosmopolitan characteristics from the surface to the bottom of water bodies. In addition, these diatoms can adapt to the environmental conditions at each research station and are influenced by water nutrient concentrations (Tarigas, 2020).

The lowest diatom composition was found at Station III, while the highest was at Station I. The high diatom composition at the station may influence the type of seagrass, as older seagrass has higher epiphytic composition and density than younger seagrass. This is because the leaves, stems, and roots of older seagrass can greatly aid the attachment and colony formation of diatoms (Akbar et al., 2020). Older seagrass leaves also tend to have a more complex structure and a larger surface area. Research shows that older seagrass can support a more diverse and dense epiphytic diatom community, which, in turn, increases diatom composition (Nilamsari et al., 2024).

Abundance of Epiphytic Diatoms

The average epiphytic diatom abundance on *T. hemprichii* seagrass leaves is shown in Table 3.

Table 3. Average abundance of epiphytic diatoms on *T. hemprichii* seagrass leaves

Station	Transect	Plot	Total abundance value (ind/cm^2)	Average abundance of epiphytic diatoms per plot	Average abundance value of epiphytic diatoms (ind/cm^2)
I	I	I	5.362		
		II	2.145	3.217	
		III	2.145		
	II	I	4.504		
		II	6.648	4.432	3.789
		III	2.145		
	II	I	3.431		
		II	3.860	3.717	
		III	3.860		
II	I	I	3.646		
		II	1.501	3.146	
		III	4.289		
	II	I	1.501		
		II	2.359	2.788	2.693
		III	4.504		
	III	I	1.930		
		II	2.788	2.145	
		III	1.716		
III	I	I	2.788		
		II	1.930	2.073	
		III	1.501		
	II	I	1.716		
		II	1.287	1.787	2.002
		III	2.359		
	III	I	2.788		
		II	2.145	2.145	
		III	1.501		

The highest abundance was observed at station I, with an average abundance of 3,789 ind/cm^2. In comparison, the lowest abundance was found at station III with an average abundance value of 2,002 ind/cm^2. The high abundance value at Station I may be due to the water quality in the area where seagrass vegetation grows, which has high nutrient content, affecting its abundance and type. The differences in abundance observed at the study site indicate variation in epiphytic diatom species (Samosir et al., 2022).

The high average abundance at Station I is due to water being close to wastewater discharges around the study area, including domestic wastewater and ship fuel residues dumped into the sea. These wastes contain nitrate and phosphate, which serve as food sources and can stimulate the growth of microalgae, including diatoms (Samosir et al., 2022). Phytoplankton abundance increases in tandem with rising nitrate levels. Specifically, Person et al. in Permatasari (2016) explain that the minimum nitrate requirement for diatom absorption ranges from 0.001 to 0.007 mg/L. However, excess phosphate is detrimental to water bodies, as supported by Ugrosono in Asih et al. (2022), who noted that wastewater from ponds still contains pollutants from leftover feed, microorganisms, and disease pathogens from pond animals.

The high abundance of epiphytic diatoms at station I may also be due to relatively calm currents, as lower current speeds favor organisms that attach to the substrate. Additionally, it may be due to the station's shallower depth. As stated by Purnawan et al. (2016), shallow water conditions result in high light intensity accompanied by nutrient input, thereby providing opportunities for diatom growth. Temperature also affects diatom abundance, as measured at Stations I (33°C), II (33°C), and III (34°C).

The relatively high temperature at the study site was due to sampling during hot weather, which led to warmer seawater. The water temperature is still considered good because higher temperatures facilitate photosynthesis in seagrass leaves. Dissolved oxygen (DO) levels measured in the waters of Cindakir Beach range from 8.976 to 11.016 mg/L. This value is still suitable for diatom life. According to Reynolds in Permatasari (2016), diatoms can survive at dissolved oxygen levels of 7–11 mg/L, though some diatom species can survive below 6.5 mg/L.

The abundance of epiphytic diatoms was relatively low compared to the study by Hayati et al. (2023) in the waters of Feri Tomia, which reported abundances of 7,785–18,474 ind/cm^2. Furthermore, the study by Devayani et al. (2019) in the waters of Karimunjawa Island showed an abundance of 6,717–8,808 ind/cm^2, and the study by Hayati et al. (2023) on Poncan Gadang Island with abundance values ranging from 2,160.85 to 4,649.94 ind/cm^2, but it is relatively high compared to the study by Rambe et al. (2020) in the waters of Nirwana Beach with abundance values of 873-1,895 ind/cm^2. It is also considered high compared to the study by Puspita et al. (2021), which reported diatom abundance at Pandaratan Beach ranging from 663.41 to 932.21 ind/cm^2. Thus, the range of diatom abundance values found in the waters of Cindakir Beach is still within the general range.

Diversity Index, Dominance Index, and Evenness Index of Epiphytic Diatoms.

The structure of the epiphytic diatom community can describe the stability of a seagrass ecosystem. The community structure consists of the Diversity Index (H'), Dominance Index (D), and Evenness Index (E) values, which can be seen in Table 4.

From the data analysis, the diversity index (H') of epiphytic diatoms at each station ranged from 0.9254 to 2.2010, with an average value of 1.5944. The diversity index in this water body falls into the category of moderate species diversity, where 1 < H' < 3. Based on the pH measurements at stations I, II, and III, all at 7, the pH supports diatom growth. Optimal pH values are crucial for diatom physiological processes, as within this range, diatom diversity increases (Gualtieri in Permatasari, 2016).

Table 4. Average Diversity Index (H'), Dominance Index (D), and Evenness Index (E) of epiphytic diatoms

Station	Transect	H'	D	E
I	I	1,2460	0,4680	0,8414
	II	1,4576	0,3971	0,8538
	III	0,9254	0,6566	0,5845
	Avarage	1,2097	0,5072	0,7599
II	I	2,2010	0,2364	0,9539
	II	1,8570	0,2994	0,9285
	III	1,6713	0,3266	0,9706
	Avarage	1,9098	0,2875	0,9510
III	I	1,7220	0,3245	0,9243
	II	1,5619	0,3442	0,9855
	III	1,7071	0,3663	0,9064
	Avarage	1,6637	0,3450	0,9387

Among the three research stations, the highest average diversity index (H') value was found at Station II with a value of 1.9098, followed by Station III with an average value of 1.6637, and the lowest average value was found at Station I with a value of 1.2097. According to

Akbar et al. (2020), the high or low values of the species diversity index are influenced by oceanographic factors such as currents. According to Ghazali et al. (2018), current speed significantly influences the likelihood of epiphytic diatoms attaching to seagrass.

The Dominance Index (C) is used to determine whether there are any dominant species in the water. The dominance index in the waters of Cindakir Beach ranges from 0.2364 to 0.6566, with an average of 0.3799, indicating a dominant species at one of the research stations. Where the dominance index (D) of diatoms at Station I ranges from 0.3971 to 0.6566 with an average of 0.5072, at Station II, it ranges from 0.2364 to 0.3266 with an average of 0.2875, and at Station III, it ranges from 0.3245 to 0.3663 with an average of 0.3799. Based on the data obtained, it can be said that a dominant species occurs at station I, specifically at transect III, plot III.

The Species Uniformity Index (E) in the waters of Cindakir Beach ranges from 0.5845 to 0.9855, with an average value of 0.8832. The species uniformity criteria for diatoms fall into the high category, where the species uniformity index for epiphytic diatoms at Station I ranges from 0.5845 to 0.8538 with an average value of 0.7599, at Station II ranging from 0.9285 to 0.9706 with an average of 0.9510, and at Station III ranging from 0.9064 to 0.9855 with an average value of 0.9387. According to Tarigas et al. (2020), the higher the species uniformity index value, the more evenly distributed the number of individuals per genus is, with no single genus dominating.

Measurement of Water Quality Parameters

The waters of Cindakir Beach can still support the growth and spread of epiphytic diatoms and photosynthesis. The salinity measurements obtained ranged from 28 to 30 ‰. This salinity is relatively low for seagrass biota, according to Government Regulation of the Republic of Indonesia Number 22 of 2021, which stipulates a range of 33-34‰. However, according to the regulation, salinity may vary by up to 5% from the average seasonal salinity.

Observations of water quality parameters, including physical and chemical characteristics, were conducted to describe the relationship between seaweed characteristics and community activities in the waters of Cindakir Beach (Table 5).

Table 5. Water quality parameters at Cindakir Beach

No	Water quality	Satuan (unit)	Station			Seawater Quality Standards*
			I	II	III	
1	Temperature	ºC	33	34	33	28-30º
2	Salinity	Ppt	29	28	30	33-34
3	pH		7	7	7	7-8,5
4	Current velocity	m/s	0,071	0,076	0,069	-
5	DO	mg/L	9,792	11,016	8,976	>5
6	Light intensity	M	0,02	0,04	0,03	>3
7	Nitrate	mg/L	0,458	0,110	0,412	0,06
8	Phosphate	mg/L	0,329	0,267	0,234	0,015

Description: *Government Regulation No. 22 of 2021

4. CONCLUSION

Based on research in the waters of Cindakir Beach, diatoms from the Bacillariophyceae class were found, consisting of 14 species of epiphytic diatoms. The highest abundance was found at station I, and the lowest at station III, which is related to water quality conditions that are still good for diatoms at Cindakir Beach.

The diversity index (H') of epiphytic diatoms falls into the category of moderate species diversity. The dominance index (D) indicates that dominant diatom species occur at station I. The evenness index (E) is classified as even or stable, which means that species evenness at the research site is balanced.

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