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Dataset on the Diversity of Epipelic Diatoms in Sediment Layers as Bioindicators of Aquatic Environment

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ABSTRACT

Environmental degradation caused by industrial development and urbanization poses significant threats to aquatic ecosystems, emphasizing the urgent need for effective monitoring tools. Diatoms, highly adaptable microalgae, serve as bioindicators of environmental change due to their sensitivity to variations in water quality. This study aimed to investigate the diversity of epipelic diatoms in sediment layers of intertidal waters in Dumai City, Riau, to assess their potential as indicators of aquatic environmental health. This research was conducted from May to October 2022 in the intertidal waters of Dumai City, Riau. The method used was the survey method, and purposive sampling was conducted at four stations, namely Dumai River Estuary (ST1), Masjid River Estuary (ST2), Bangsal Aceh Industrial Area (ST3), and Koneng Beach (ST4). Sediment samples were collected from ten depth intervals (0–5cm to 46–50cm) to evaluate species distribution, diatom abundance, and ecological indices, including diversity (H'), dominance (D), and uniformity (E). Results revealed 25 diatom species, with the highest abundance in the 0–5cm sediment layer, particularly at ST2, which exhibited elevated nitrate and phosphate levels. The diversity index (2.06–2.98) indicated balanced biotic communities, while dominance and uniformity indices suggested an absence of competitive exclusion and a stable ecological state. These findings highlight the value of diatom diversity as a bioindicator for monitoring nutrient pollution and environmental health. Water quality in Dumai City is still in the tolerable range for diatom abundance and survival. This study highlights the potential of epipelic diatoms as biological indicators for assessing the impact of anthropogenic activities and environmental changes on Dumai's aquatic ecosystems.

INTRODUCTION

Dumai is one of the Riau provinces directly adjacent to the strait of Malacca, an international shipping lane **(Ariani *et al.*, 2021)**. The development of all sectors in Dumai City continues to increase, making Dumai City an industrial area on the east coast of Sumatra. Several large industries with international capacity have been established in the

Dumai coastal area, such as Pertamina Dumai oil refinery, PT Chevron Indonesia, palm oil processing companies and wood raw material processing, and port activities for loading and unloading goods and people **(Aini *et al.*, 2019)**. These activities generate waste for the environment that can adversely affect the survival and growth of aquatic organisms and impact the cleanliness of drinking water **(Acholonu *et al.*, 2023)**.

The Dumai waters support various economic and industrial functions, making it an area of ecological and environmental significance, such as settlements and housing, settlements, small-scale fishing activities and industries, as well as tourism and mangrove areas. Organic matter that enters the waters can come from household waste, agricultural waste, and oil refining. Pollution of water bodies by industrial effluents affects aquatic flora and fauna and poses a significant risk to human health by contaminating groundwater and agricultural products. This can disrupt the ecology and can pose a severe risk. Ecological changes can be seen based on biological indicators, such as the presence and ability of aquatic biota to survive in their habitat, one of which is diatoms.

Diatoms, unicellular eukaryotic microalgae, are widely recognized as effective bioindicators for assessing water quality due to their sensitivity to environmental changes **(Sharma *et al.*, 2023)**. These organisms respond quickly to variations in nutrient availability, ion concentrations, and organic content, making them valuable for monitoring the condition of a water body and for detecting anthropogenic impacts, such as pollution from domestic sewage and industrial effluents **(Madhankumar & Venkatachalapathy, 2023)**. Physical and chemical conditions largely determine the presence of diatoms in waters, as diatoms have certain tolerance limits. Environmental factors, such as depth, influence the type and distribution of diatoms in a water body. For example, in Bolshoe Lake of the sub-arctic store, water depth significantly influences diatom diversity, with unique taxonomic compositions observed in nearshore and lagoonal locations and phylogenetic solid clustering in deeper waters **(Stoof-Leichsenring *et al.*, 2020)**.

In addition, diatom diversity and abundance can reduce erosion and can maintain habitat structure for other marine organisms **(Poulickova *et al.*, 2014)**, indicate the level of pollution in waters **(Guardia *et al.*, 2024)**. In addition, its diversity and abundance can maintain nutrient balance and support diverse aquatic life **(Tekwani *et al.*, 2014)**. The advantages of using epipelic diatoms as bioindicators in this study, compared to other bioindicators, include the following: Epipelic diatoms are ubiquitous in aquatic environments, ensuring broad applicability across different ecosystems **(Poulickova *et al.*, 2014)**. Epipelic diatoms in sediment layers provide insights into past environmental conditions, offering a temporal dimension to water quality assessment **(Thacker & Karthick, 2024)**.

Despite their known effectiveness as bioindicators, there is limited information on the diversity and distribution of epipelic diatoms in Dumai's sediment layers. This research aimed to fill that gap by examining diatom diversity across sediment depths and linking their abundance and distribution to water quality parameters. The findings are critical for establishing a baseline for monitoring the ecological health of Dumai's intertidal waters and for assessing sustainable management strategies.

MATERIALS AND METHODS

Time and place

This research was conducted from May to October 2022 in the intertidal waters of Dumai City, Riau Province (Fig. 1). Biological parameters (community structure and diatom abundance) were analyzed in the Marine Biology Laboratory, and physicochemical parameters were conducted at the Chemistry Laboratory of the Department of Marine Science, Faculty of Fisheries and Marine Sciences, Universitas Riau.

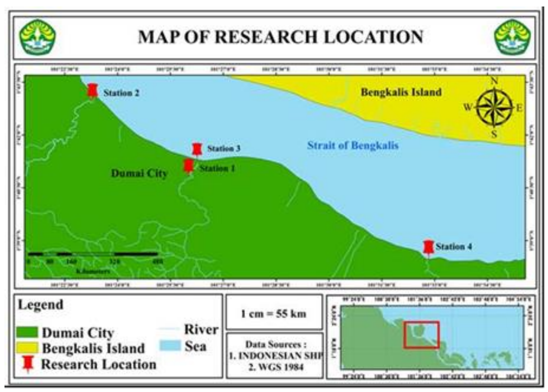

Fig. 1. Research location

Methods

The method used in this study is a survey method carried out by observation, measurement, and sampling directly in the field, then continued with the identification of plankton samples in the Marine Biology Laboratory, Department of Marine Sciences, Faculty of Fisheries and Marine Sciences, Universitas Riau.

Procedures

Determination of sampling locations

The sampling location of biological (diatom) physical and chemical parameters was determined by purposive sampling. Stations and sampling points of plankton samples were determined by purposive sampling based on anthropogenic activities around the waters. In this study, three observation stations were set, which were considered to represent the environmental conditions of the study. Each station is divided into three sampling points based on the intertidal zone, namely in the highest tide zone (upper zone), the highest tide limit zone with the lowest tide (middle zone), and the lowest tide limit zone (lower zone). Diatom samples based on water depth for sampling locations can be seen in Table (1).

Table 1. Sampling location

Station	Description	
I	At the Estuary of the Dumai River	Urban settlements, domestic wastewater, and small-scale fishing activities
II	In the Estuary of the Dumai Mosque River	Dominated by mangrove ecosystems
III	In the Industrial Area of Bangsal Aceh	Industrial area
IV	In the Koneng Beach area	A recreational area

Epipelic diatom sampling

The diatom sampling technique was carried out vertically in the sediment, using a modified corer with stainless steel (1m long and 5cm in diameter) (Fig. 2) and from the samples obtained, taken per layer, namely at a depth of 0 - 5cm, 6 - 10cm, 11 - 15cm, 16 - 20cm, 21 - 25cm, 26 - 30cm, 31 - 35cm, 36 - 40cm, 41 - 45cm, and 46 - 50cm. This study's selection of depth intervals (0–5cm, 6–10cm, and 11–15cm) was based on sediment layers' biological and ecological relevance in influencing diatom diversity and abundance. Sediment depth can significantly impact the microhabitat characteristics, including light penetration, organic matter availability, and nutrient concentration, which are critical for epipelic diatoms' survival and distribution. These intervals capture the vertical stratification of diatoms and their response to environmental changes.

At the depth limit, the sediment is still in mud and diatoms, while at a depth of > 50cm, the sediment is already in the form of hard soil and is difficult to reach. After that, 5cm thick sediment samples were taken from each layer. Sediment samples were put into plastic and were then given a sample code. The remaining sediment samples were used for organic matter and sediment fraction tests. Sediment samples of 5cm thick from each layer were placed in a sample bottle containing 100ml of distilled water and were gently shaken clockwise. Samples were preserved using 4% Lugol, labeled, and put in an ice box for observation.

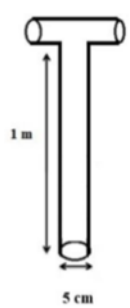

Fig. 2. Diatom sampling corer

Diatom sample observation

Observations of diatoms were carried out using an Olympus CX 21 microscope with a magnification of 10 x 10 used to find diatoms and 10 x 40 used for identification. Observations using the field of view method with one observation of 12 fields. Observations were made three times for each sample bottle; epipelic diatom water samples were stirred so that the diatoms were evenly distributed and had the same opportunity. The observed diatoms were identified using an identification book **(Bainbridge & Davis, 1956)**.

Data analysis

Calculation of abundance of epipelic diatoms

The abundance of diatoms was calculated using the modified Lackey Drop Microtransecting Methods formula.

$$N = \frac{30i}{Op} \times \frac{Vr}{3Vo} \times \frac{1}{A} \times \frac{n}{3p}$$

Where:

N = Number of epipelic diatoms per unit area (individuals/cm^2)
Oi = Area of cover glass (25 x 25 mm = 625 mm^2)
Op = Unit area of view of Olympus CX 21 microscope magnification 10x10 (1.306 mm^2)
Vr = Volume of sample water in sample bottle (100 mL)
Vo = The volume of 1 drop of the sample (0.06 mL)
A = Area of the scallop field (25 cm^2)
n = The number of epipelic diatoms counted
P = Number of field of view (12)

Species diversity index (H')

The species diversity index was used to see the diversity of diatom species using the Shannon-Winner formula **(Odum, 1971)**:

$$H' = -\sum_{i=1}^{s} pi\ Log_2\, pi$$

Where:

Log_2 = 3,3219
H' = Species diversity index
Pi = Share of individuals of the i-th species to total individuals of all species (pi = ni/N)
Ni = Total number of individuals of the i-th species (individuals/cm^2)
N = Total individuals of all species (individuals/cm^2)

S = The number of individuals

With criteria: H' < 1= Biota community is not balanced, or water quality is heavily polluted; 1< H'<3 = Biota community balance is moderate, and water quality is moderately polluted; H' > 3 = Biota balance is in excellent condition and water quality is clean.

Dominance index (D)

The dominance index was used to calculate the dominance index of diatoms in sediments using Simpson's formula **(Odum, 1971)** as follows:

$$D = \sum_{i=1,2,3}^{s} \left(\frac{ni}{N}\right)^2$$

Where:

Ni = Total number of individuals of the i-th species (individuals/cm^2)

N = Total individuals of all species (individuals/cm^2)

With criteria: D close to 0 (< 0.5) = No dominant species; D close to 1 (> 0.5) = Dominant species.

Species diversity index (E)

The species uniformity index was used to see if the uniformity of epipelic diatom organisms was in a balanced state or not, which was calculated using Pilou's formula **(Odum, 1971)** as follows:

$$E = \frac{H'}{Log_2 S}$$

Where: E = Species uniformity index

H' = Species diversity index

S = number of species encountered

With the criteria, if the value of E: Approaching 1 (> 0.5), then the uniformity of organisms is in a balanced state, and there is no competition for both place and food; Approaching 0 (< 0.5) means that the uniformity of organisms in the waters is not balanced, and there is competition for food.

Water quality

The water quality parameters measured include brightness, temperature, current velocity, salinity, pH nitrate, and phosphate. Before sampling, each station was measured three times at low tide.

Data analysis

Data from the abundance of epipelic diatom measurements were collected and tabulated in Table. Next, they were analyzed statistically using the SPSS version 26 application and One-way ANOVA. If the analysis results showed an influence, a further test was carried out using Student Newman Keuls (SNK).

RESULTS

1. Species, distribution, and abundance of epipelic diatoms

Based on depth, 25 species of epipelic diatoms were found in the waters of Dumai City.

Table 2. Types of epipelic diatoms found at Station I

No	Species name	Station I									
		5	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
1	*Amphipleura* sp.	+	+	+	+	+	+	+	+	+	+
2	*Aulacoseira* sp.	-	-	-	-	-	-	+	-	-	-
3	*Cocconeis* sp.	-	-	-	-	-	+	-	+	+	+
4	*Coscinodiscus* sp.	+	+	+	+	+	+	+	+	+	+
5	*Cymbella* sp.	-	-	-	-	-	-	+	+	-	-
6	*Diadesmis* sp.	+	+	-	-	-	-	-	-	-	-
7	*Diplemonera* sp.	-	-	-	-	+	-	-	-	-	-
8	*Epithemia* sp.	+	+	+	+	+	+	-	+	+	+
9	*Gyrosigma* sp.	+		+	+	-	-	-	-	-	-
10	*Isthmia* sp.	+	+	+	+	+	+	+	+	-	-
11	*Navicula* sp.	+	+	+	+	+	-	-	+	-	-
12	*Nitzschia* sp.	-	-	-	+	+	-	-	-	-	-
13	*Pinnularia* sp.	-	-	+	+	+	+	+	-	+	+
14	*Pleurosigma* sp.	+	+	+	+	-	-	-	-	-	-
15	*Rhizosolenia* sp.	-	+	+	+	-	+	-	-	+	+
16	*Sellaphora* sp.	-	-	-	-	+	-	+	-	+	+
17	*Skeletonema* sp.	-	-	-	-	-	-	-	-	+	-
18	*Stauroneis* sp.	-	-	-	+	+	-	-	-	-	-
19	*Stephanodiscus*	+	-	+	+	+	-	+	+	+	-
20	*Striatella* sp.	-	-	-	-	-	-	-	-	-	+
21	*Surirella* sp.	-	+	-	-	+	+	-	-	-	-
22	*Synedra* sp.	+	+	+	+	+	+	+	+	+	+
23	*Thalassiosira* sp.	+	+	-	-	-	-	-	-	-	-
24	*Triceratium* sp.	-	-	+	+	+	+	+	+	+	+
25	*Ulnaria* sp.	+	-	-	-	-	+	+	+	+	+
	Total	**12**	**11**	**12**	**14**	**14**	**11**	**11**	**11**	**12**	**11**

Table 3. Types of epipelic diatoms found at Station II

No	Species name	Station II									
		5	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
1	*Amphipleura* sp.	+	+	+	+	+	+	+	+	+	+
2	*Aulacoseira* sp.	+	-	+	+	-	+	+	+	+	+
3	*Cocconeis* sp.	-	+	+	+	-	+	+	-	+	+
4	*Coscinodiscus* sp.	+	+	+	+	+	+	+	+	+	+
5	*Cymbella* sp.	-	-	+	+	-	-	-	-	-	-
6	*Diadesmis* sp.	+	-	-	-	-	-	-	-	-	-
7	*Diplemonera* sp.	+	-	-	-	-	-	-	-	-	-
8	*Epithemia* sp.	+	+	+	+	+	+	+	+	+	+
9	*Gyrosigma* sp.	+	+	+	-	-	+	-	+	+	-
10	*Isthmia* sp.	+	+	-	+	+	+	+	+	+	+
11	*Navicula* sp.	+	+	+	+	+	+	+	+	+	-
12	*Nitzschia* sp.	+	+	-	-	-	-	-	-	-	-
13	*Pinnularia* sp.	+	+	+	+	+	+	+	+	+	+
14	*Pleurosigma* sp.	+	+	+	+	+	+	+	+	+	-
15	*Rhizosolenia* sp.	+	+	-	-	-	-	-	+	-	+
16	*Sellaphora* sp.	+	+	-	-	+	-	+	-	-	+
17	*Skeletonema* sp.	+	+	+	+	+	+	-	-	-	-
18	*Stauroneis* sp.	+	-	-	+	+	-	+	-	+	+
19	*Stephanodiscus*	+	+	+	+	+	+	+	+	+	+
20	*Striatella* sp.	-	-	-	-	+	+	-	-	-	-
21	*Surirella* sp.	+	-	-	-	-	-	-	-	-	-
22	*Synedra* sp.	+	+	+	+	+	+	+	+	+	+
23	*Thalassiosira* sp.	-	+	+	+	+	+	+	+	+	+
24	*Triceratium* sp.	-	+	+	+	-	-	+	-	+	-
25	*Ulnaria* sp.	+	+	-	-	+	-	+	-	-	-
	Total	**23**	**20**	**15**	**19**	**16**	**17**	**17**	**14**	**16**	**15**

Table 4. Types of epipelic diatoms found at Station III

No	Species name	Station III									
		5	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
1	*Amphipleura* sp.	+	+	+	+	+	-	-	-	+	-
2	*Aulacoseira* sp.	+	+	+	+	+	+	+	+	+	+
3	*Cocconeis* sp.	+	-	-	-	+	-	+	-	-	-
4	*Coscinodiscus* sp.	-	-	-	-	-	-	-	+	-	-
5	*Cymbella* sp.	+	+	+	+	+	+	+	+	+	+
6	*Diadesmis* sp.	+	+	+	+	+	+	+	+	+	+
7	*Diplemonera* sp.	+	-	+	-	+	-	-	-	-	-
8	*Epithemia* sp.	+	+	+	+	+	-	+	+	-	-
9	*Gyrosigma* sp.	+	+	+	+	+	+	+	-	+	+
10	*Isthmia* sp.	+	+	+	+	+	+	+	+	+	-
11	*Navicula* sp.	+	+	-	+	+	+	+	-	-	-
12	*Nitzschia* sp.	+	+	+	+	+	+	+	+	+	-
13	*Pinnularia* sp.	-	-	+	-	-	-	-	-	-	-
14	*Pleurosigma* sp.	+	+	+	+	-	+	+	-	-	-
15	*Rhizosolenia* sp.	+	+	+	+	+	+	+	+	+	+

16	*Sellaphora* sp.	+	+	+	+	+	+	+	+	-	+
17	*Skeletonema* sp.	-	-	-	-	-	+	+	+	+	-
18	*Stauroneis* sp.	-	-	+	-	+	+	+	-	-	-
19	*Stephanodiscus*	-	+	-	+	-	-	-	-	+	-
20	*Striatella* sp.	+	+	+	+	+	+	+	+	+	+
21	*Surirella* sp.	-	-	-	-	-	-	-	-	+	-
22	*Synedra* sp.	+	+	+	+	+	+	+	+	+	+
23	*Thalassiosira* sp.	+	+	+	+	+	+	+	+	+	+
24	*Triceratium* sp.	+	+	-	-	-	-	-	-	-	-
25	*Ulnaria* sp.	-	-	+	+	-	+	-	+	-	-
	Total	**18**	**17**	**18**	**17**	**17**	**16**	**17**	**14**	**14**	**9**

Table 5. Types of epipelic diatoms found across Station IV

No	**Species name**	**Station IV**									
		5	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
1	*Amphipleura* sp.	+	+	+	+	+	-	-	-	+	-
2	*Aulacoseira* sp.	+	+	+	+	+	+	+	+	+	+
3	*Cocconeis* sp.	+	-	-	-	+	-	+	-	-	-
4	*Coscinodiscus* sp.	-	-	-	-	-	-	-	+	-	-
5	*Cymbella* sp.	+	+	+	+	+	+	+	+	+	+
6	*Diadesmis* sp.	+	+	+	+	+	+	+	+	+	+
7	*Diplemonera* sp.	+	-	+	-	+	-	-	-	-	-
8	*Epithemia* sp.	+	+	+	+	+	-	+	+	-	-
9	*Gyrosigma* sp.	+	+	+	+	+	+	+	-	+	+
10	*Isthmia* sp.	+	+	+	+	+	+	+	+	+	-
11	*Navicula* sp.	+	+	-	+	+	+	+	-	-	-
12	*Nitzschia* sp.	+	+	+	+	+	+	+	+	+	-
13	*Pinnularia* sp.	-	-	+	-	-	-	-	-	-	-
14	*Pleurosigma* sp.	+	+	+	+	-	+	+	-	-	-
15	*Rhizosolenia* sp.	+	+	+	+	+	+	+	+	+	+
16	*Sellaphora* sp.	+	+	+	+	+	+	+	+	-	+
17	*Skeletonema* sp.	-	-	-	-	-	+	+	+	+	-
18	*Stauroneis* sp.	-	-	+	-	+	+	+	-	-	-
19	*Stephanodiscus*	-	+	-	+	-	-	-	-	+	-
20	*Striatella* sp.	+	+	+	+	+	+	+	+	+	+
21	*Surirella* sp.	-	-	-	-	-	-	-	-	+	-
22	*Synedra* sp.	+	+	+	+	+	+	+	+	+	+
23	*Thalassiosira* sp.	+	+	+	+	+	+	+	+	+	+
24	*Triceratium* sp.	+	+	-	-	-	-	-	-	-	-
25	*Ulnaria* sp.	-	-	+	+	-	+	-	+	-	-
	Total	**18**	**17**	**18**	**17**	**17**	**16**	**17**	**14**	**14**	**9**

Epipelic diatoms were distributed at several depths, with the highest number found at 0-5cm depth, namely Station 2 (23 species). Epipelic diatoms are generally found in the surface layer (0-5cm). While the depth> 36cm, the number of diatoms found continues to decline. More details can be seen in Fig. (3).

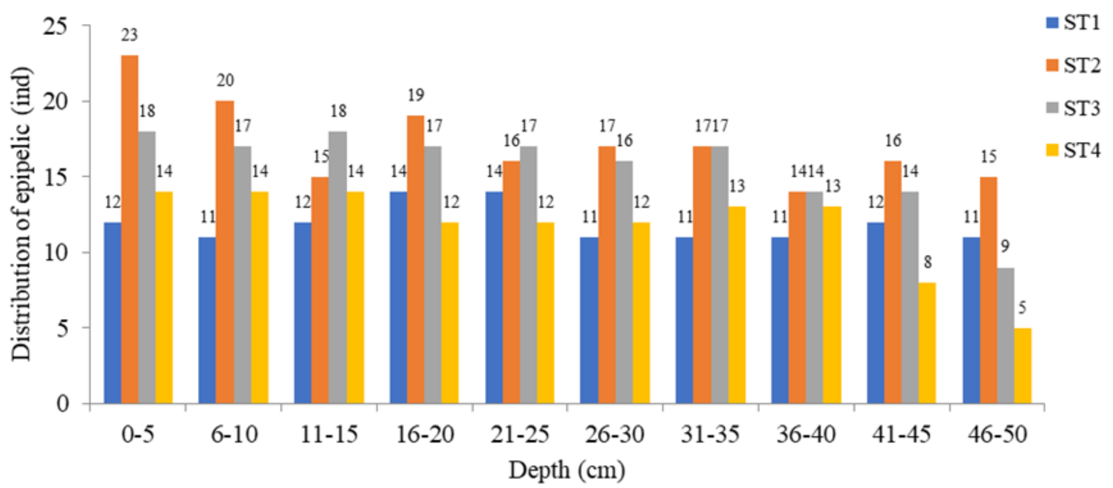

Fig. 3. Distribution of epipelic diatoms by depth

The abundance of epipelic diatoms at each station fluctuated between 23,729 & 275,706 ind/cm^2. The highest abundance of epipelic diatoms was found at 0-5cm depth, and the lowest at 46-50cm depth. More details can be seen in Fig. (4).

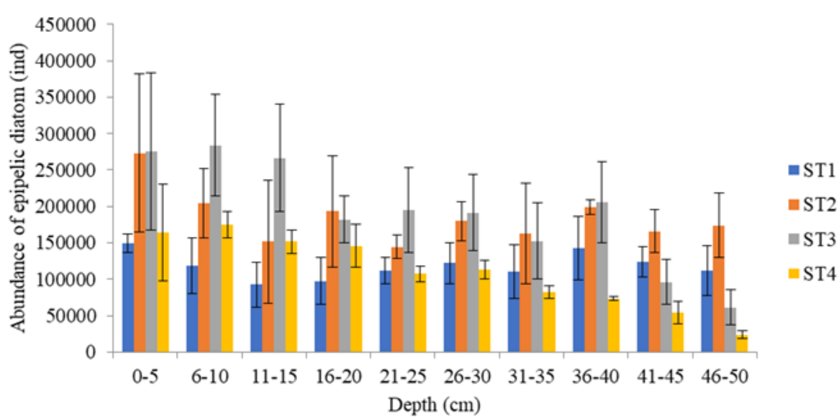

Fig. 4. Abundance of epipelic diatoms

2. Epipelic diatom community structure

The community structure of epipelic diatoms in Dumai City Waters obtained species diversity values ranging from 2.06-2.98, which indicates a moderate biota balance. Furthermore, the dominance index in the waters of Dumai City ranges from 0.15-0.41 (<0.5), indicating no dominant species. The species evenness index in the seas of Dumai City ranged from 0.53-0.90 (E>0.5), indicating the uniformity of organisms in a state of balance and no competition in obtaining food (Table 6).

Table 6. Diversity index (H'), dominance index (D), and index (E) of epipelic diatoms

Depth	H				D				E			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
0-5	2.18± 0.93	2.94± 0.39	3.07± 0.30	2.87± 0.29	1.28± 1.57	0.16± 0.05	0.13± 0.04	0.17± 0.02	0.60± 0.24	0.75± 0.10	0.91± 0.04	0.89± 0.02
6-10	2.36± 0.28	2.90± 0.50	2.99± 0.32	2.70± 0.34	0.23± 0.04	0.20± 0.07	0.15± 0.04	0.19± 0.04	0.60± 0.07	0.74± 013	0.89± 0.08	0.87± 0.05
11-15	2.05± 0.19	2.50± 0.51	3.01± 0.18	2.64± 0.15	0.30± 0.06	0.27± 0.10	0.14± 0.01	0.20± 0.02	0.55± 0.09	0.64± 0.13	0.96± 0.04	0.88± 0.05
16-20	2.13± 0.29	2.97± 0.26	3.10± 0.36	2.51± 0.04	0.27± 0.05	0.18± 0.05	0.14± 0.04	0.22± 0.03	0.55± 0.07	0.76± 0.07	0.91± 0.04	0.84± 0.06
21-25	2.28± 0.55	2.52± 0.69	2.92± 0.29	2.69± 0.23	0.29± 0.13	0.27± 0.14	0.16± 0.04	0.18± 0.03	0.58± 0.14	0.65± 0.18	0.87± 0.02	0.94± 0.04
26-30	1.63± 0.10	1.03± 1.46	3.06± 0.22	2.73± 0.43	0.43± 0.06	0.20± 0.14	0.14± 0.03	0.17± 0.04	0.42± 0.06	0.70± 0.06	0.92± 0.04	0.92± 0.06
31-35	1.81± 0.10	2.80± 0.12	3.10± 0.04	2.41± 0.57	0.37± 0.07	0.17± 0.12	0.13± 0.04	0.22± 0.08	0.46± 0.03	0.72± 0.03	0.94± 0.03	0.95± 0.02
36-40	2.07± 0.14	2.49± 0.21	2.81± 0.05	2.47± 0.51	0.27± 0.02	0.25± 0.07	0.17± 0.05	0.20± 0.06	0.53± 0.04	0.64± 0.05	0.92± 0.04	0.92± 0.06
41-45	2.16± 0.16	2.61± 0.23	2.71± 0.33	2.04± 0.44	0.29± 0.05	0.22± 0.07	0.18± 0.04	0.27± 0.07	0.55± 0.04	0.67± 0.06	0.89± 0.03	0.95± 0.02
46-50	1.97± 0.17	2.46± 0.54	2.52± 0.41	1.74± 0.21	0.34± 0.02	0.23± 0.07	0.21± 0.06	0.32± 0.05	0.50± 0.04	0.63± 0.14	0.91± 0.02	0.94± 0.06
Average	2.06± 0.38	2.52± 0.74	2.93± 0.32	2.48± 0.45	0.41± 0.51	0.21± 0.07	0.15± 0.04	0.21± 0.06	0.53± 0.10	0.69± 0.10	0.90± 0.04	0.90± 0.05

3. Water quality parameters

Water quality is one of the crucial factors in the presence of diatoms in a water body. The presence of diatoms reflects the impact of pollutants and other anthropogenic activities in a body of water. Water quality parameters in several waters in Dumai City are illustrated in Table (7).

Table 7. Measurement of water quality in Dumai City

Parameter	**Station**				**Quality standard**
	1	**2**	**3**	**4**	
Temperature (°C)	28,33	27,33	28	33	20-30 **(Mesquita *et al.* 2023)**
Current speed (m/s)	0,27	0,10	0,32	30,12	0.15- 0.4 **(Lamb and Lowe, 1987)**
Brightness (cm)	33,5	68,6	63,7	57,3	33.5–68.6 **(Prasiska *et al.* 2020)**
Salinity (‰)	24,33	13,33	16	17,6	13.33–24.33 **(Bak *et al.* 2020)**
pH	7	8,4	6,3	8,13	6.5-8.5 **(Madhankumar and Venkatachalapathy, 2023)**
Nitrate (mg/L)	0,84	1,13	0,74	0,97	0.5-2 **(Tampubolon *et al.* 2020)**
Phosphate (mg/L)	0,77	1	0,93	1,05	0.1 – 2 **(Beranda *et al.* 2020)**

DISCUSSION

Species, distribution, and abundance of epipelic diatoms

Epipelic diatoms are attached to the bottom substrate of aquatic environments, showing different distribution patterns based on depth, and they are influenced by various environmental factors. Diatoms are used as bioindicators due to their sensitivity to environmental changes. There were 25 epipelic diatom species found in the waters of Dumai City, namely *Aulacoseira* sp., *Nitzschia* sp., *Isthmia* sp., *Coscinodiscus* sp., *Cymbella* sp., *Synedra* sp., *Diadesmis* sp., *Stephanodiscus* sp., *Ulnaria* sp., *Melosira* sp., *Stauroneis* sp., *Frustulia* sp., *Gyrosigma* sp., *Navicula* sp., *Pinnularia* sp., *Pleurosigma* sp., *Sellaphora* sp., *Oscillatoria* sp., *Rhizosolenia* sp., *Epithemia* sp., *Striatella* sp., *Surirella* sp., *Skeletonema* sp., *Thalassiosira* sp., and *Triceratium* sp. (Table 1).

Navicula sp., *Coscinodiscus* sp., *Pinnularia* sp., *Synedra* sp., and *Thalassiosira* sp. were distributed at each station at the surface (0-5cm). According to **Shaimaa *et al.* (2023)**, 161 species were found in the Tigris River, with genera such as Nitzchia and Navicula reflecting water quality and pollution levels. *Synedra* sp., identified in Muara Suwung, can be used as a bioindicator due to its sensitivity to environmental changes **(Supono & Hudaidah, 2018)**. Furthermore, *Thalassiosira* sp. was found in surface waters and was used as a bioindicator of the aquatic environment **(Petrov & Nevrova, 2020)**.

The highest abundance was found in the surface layer (0-5cm) at each observation station. This is due to light availability, sediment type, and anthropological activities. **Prasiska *et al.* (2020)** stated that the abundance of diatoms is higher in the surface layer compared to deeper waters. This is related to photosynthetic activity and the availability of light underwater **(Xu *et al.*, 2022)**. Besides, the highest abundance of epipelic diatoms was found at the mouth of the Dumai Mosque River (ST2). This is thought to be due to the high content of nutrients, such as nitrate (1.13mg/ L) and phosphate (1.00mg/ L) compared to other stations (Table 4). Diatom abundance is influenced by nitrate and phosphate content, such as in Sungaitohor waters **(Beranda *et al.*, 2020)** and the waters of Nirvana Beach, West Sumatra **(Tampubolon *et al.*, 2020)**. Then, the current speed also affects the abundance of diatoms. At ST2, the current speed is relatively calmer than at other stations. According to **Wang *et al.* (2022)**, the abundance of diatoms in calm waters is higher than in high current waters so that it can reduce the abundance and diversity of species. In general, the distribution and types of epipelic diatoms are closely related to depth factors such as light availability, substrate type, nutrient concentration, and physical disturbance, highlighting the complexity and adaptability of this community in different aquatic environments.

The water quality in Dumai City supports a balanced and diverse diatom community, as evidenced by species diversity indices (2.06–2.98) and dominance indices below 0.5. These values are consistent with observations in other tropical and subtropical water bodies **(Li *et al.*, 2022; Shang *et al.*, 2023)**. In addition, the uniformity index (>0.5) indicates balanced species distribution and reduced competition for resources, aligning with the findings in comparable environments **(Dionfriski *et al.*, 2021)**.

Diatoms respond rapidly to environmental factors such as nutrient availability, light penetration, pH, and salinity variations. This study found that nitrate and phosphate concentrations were closely linked to diatom abundance, particularly in the surface layers (0–5cm), where nutrient input from anthropogenic sources is most pronounced. This concurs with the findings of **Madhankumar and Venkatachalapathy (2023)** and **Shaimaa *et al.* (2023)**, highlighting diatoms as indicators of nutrient pollution. The study's stratified that sampling by sediment depth provides insights into environmental gradients. The observed decline in diatom abundance and diversity with increasing depth reflects reduced light availability and nutrient gradients, consistent with findings in lakes and estuarine systems globally **(Stoof-Leichsenring *et al.*, 2020; Shang *et al.*, 2023)**.

Community structure of epipelic diatoms

The species diversity index is a measure used to describe the variation of species in an ecosystem. The highest level of species diversity was found in ST3 at a depth of 16-20cm, indicating a balance of biota and clean water quality. According to **Li *et al.* (2022)**, diatom diversity is relatively constant in the open deep water zone but varies in the shallow water zone due to bathymetry and sediment subsidence. **Wang *et al.* (2012)** postulated that the diversity of diatom species in Lugu Lake decreased from the shallow zone to deeper water, with a shift from periphytic to planktonic assemblages at >30m depth.

The diatom dominance index, which measures the relative abundance of diatoms compared to other phytoplankton, such as dinoflagellates, varied significantly with water depth due to different environmental conditions. Observations in Dumai City Waters showed the presence of diatoms dominating the surface waters of ST 1 (Table 3). Research conducted in Kelly Lake showed that water depth strongly influenced diatom assemblages, with different communities forming in the shallow, middle, and deep water zones **(Han *et al.*, 2023)**. In addition, the dominance of diatoms at different depths varied significantly, influenced by light availability, substrate type, and hydrological conditions **(Li *et al.*, 2022)**. The diatom dominance index is influenced explicitly by water depth, especially at depths below 10m **(Shang *et al.*, 2023)**. Generally, the dominance index at each depth at each station has a value <0.5, indicating no dominant species. This is due to the availability of nutrients and environmental conditions.

Observations showed that the species uniformity index at each depth at each station ranged from 0.5308 to 0.9042 (E>0.5), indicating a balanced state and no competition for either space or food. In Mengkapan Waters, the uniformity index of epipelic diatoms ranged from 0.6736 to 0.7755, indicating a relatively balanced distribution of species at different stations **(Dionfriski *et al.*, 2021)**. In contrast, in Sungaitohor Waters, the uniformity index was lower, averaging 0.3643, indicating an uneven distribution of diatom species. This difference in uniformity could be attributed to differences in nitrate and phosphate concentrations **(Beranda *et al.*, 2020)**. According to **Wasmund *et al.* (2017)**, a high uniformity index reflects a good environmental status. However, diversity indices often correlate poorly with environmental factors, limiting their use to control environmental quality **(Blanco *et al.*, 2012)**. In general, epipelic diatom uniformity is a complex interaction of environmental factors, nutrient levels, and water quality parameters.

Water quality

Temperature plays a vital role in determining the presence and distribution of epipelic diatoms in aquatic ecosystems. Temperature measurements during the study ranged from 28-33ºC, and diatoms can still tolerate this range. High temperatures can affect diatom communities due to competition among phytoplankton species **(Mesquita *et al.*, 2020)**. In natural environments, diatom abundance and diversity are influenced by various environmental factors, including light and water turbidity, which affect light penetration. Fluctuating light conditions affect diatoms' photosynthetic efficiency and survival **(Blommaert *et al.*, 2018)**.

Salinity significantly affects the presence and diversity of epipelic diatoms in aquatic environments, and increased salinity can affect photosynthetic activity, pigment content, growth rate, metabolism, and toxin synthesis, suggesting their acclimatization ability through adjustments in turgor pressure and ion homeostasis **(Stenger-Kovács *et al.*, 2023)**. Diatom species diversity tends to decrease with increasing salinity, as observed in the rivers of Upper Silesia, Poland, where higher salinity levels due to mining activities resulted in lower taxonomic richness and the dominance of brackish or marine species **(Bąk *et al.*, 2020)**. Furthermore, the presence of diatoms in estuarine environments reflects their high tolerance to salinity fluctuations, with many species thriving in conditions ranging from freshwater to highly saline waters. However, this broad tolerance makes them unreliable indicators for salinity assessment in some regions **(Bate *et al.*, 2013)**.

CONCLUSION

The study concluded that environmental factors significantly influence the diversity and distribution of epipelic diatoms in Dumai’s intertidal waters. A total of 25 species were identified, with the highest abundance observed in surface sediment layers (0–5cm), indicating the importance of light availability and nutrient concentration. Water quality parameters, including nitrate, phosphate, pH, and salinity, were crucial in shaping the diatom community structure. The species diversity index revealed balanced ecological conditions, and the low dominance index reflected the absence of dominant species, ensuring an evenly distributed ecosystem. These findings emphasize the potential of epipelic diatoms as effective bioindicators for monitoring water quality and informing sustainable management practices in industrial and ecological areas like Dumai.

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REFERENCES

Acholonu, C.; Bridget, E.D.; Somtochukwu, N.R.; Chinonye, E.; Okorondu, J.N. and Uyo, C. (2023). Solid Waste Disposal: A Potential Threat to Aquatic Environment. *Archives of Current Research International*, *23*(6). https://doi.org/10.9734/acri/2023/v23i6577

Aini, Z.; Mulyadi, A. and Amin, B. (2019). Analisis Komposisi Diatom Epipelik Sebagai bioindikator pencemaran perairan pantai kota Dumai Provinsi Riau. *Jurnal Penelitian Sosial Keagamaan*, *18*(1).

Ariani, F., Effendi, H. and Suprihatin, S. (2021). Analisis beban dan tingkat pencemaran di Perairan Dumai, Provinsi Riau. *Jurnal Pengelolaan Lingkungan Berkelanjutan (Journal of Environmental Sustainability Management)*, 4(2): 486-497. https://doi.org/10.36813/jplb.4.2.486-497

Bainbridge, R. and Davis, C.C. (1956). The Marine and Fresh Water Plankton. *The Journal of Ecology*, *44*(2). https://doi.org/10.2307/2256841

Bąk, M.; Halabowski, D.; Kryk, A.; Lewin, I. and Sowa, A. (2020). Mining alinisation of rivers: Its impact on diatom (bacillariophyta) assemblages. *Fottea*, *20*(1): 1–16. https://doi.org/10.5507/fot.2019.010

Bate, G.C.; Smailes, P.A. and Adams, J.B. (2013). Epipelic diatoms in the estuaries of South Africa. *Water SA*, *39*(1): 105–118. https://doi.org/10.4314/wsa.v39i1.11

Beranda, O.O.; Amin, B. and Siregar, S.H. (2020). The Relationship of Nitrate and Phosphate with Abundance of Epipelic in the Waters of Sungaitohor Village, Regency of Meranti Islands, Riau Province. *Asian Journal of Aquatic Sciences*, *3*(3): 225–235. https://doi.org/10.31258/ajoas.3.3.225-235

Blanco, S.; Cejudo-Figueiras, C.; Tudesque, L.; Bécares, E.; Hoffmann, L. and Ector, L. (2012). Are diatom diversity indices reliable monitoring metrics? *Hydrobiologia*, *695*(1). https://doi.org/10.1007/s10750-012-1113-1

Blommaert, L.; Lavaud, J.; Vyverman, W. and Sabbe, K. (2018). Behavioural versus physiological photoprotection in epipelic and epipsammic benthic diatoms. *European Journal of Phycology*, *53*(2): 146–155.

https://doi.org/10.1080/09670262.2017.1397197

Dionfriski, A.; Siregar, S.H. and Nurrachmi, I. (2021). Epipelic Diatom Community Structure in the Intertidal Zone Mengkapan Waters, Sungai Apit District, Siak Regency. *Journal of Coastal and Ocean Sciences*, *2*(3): 207-216. https://doi.org/10.31258/jocos.2.3.207-216

Han, J.; Kirby, M.; Carlin, J.; Nauman, B. and MacDonald, G. (2023). A diatom-inferred water-depth transfer function from a single lake in the northern California Coast Range. *Journal of Paleolimnology*, *70*(1). https://doi.org/10.1007/s10933-023-00281-0

Lamb, M.A. and Lowe, R.L. (1987). Effects of Current Velocity on the Physical Structuring of Diatom (Bacillariophyceae) Communities. *The Ohio Journal of Science*, 87(3): 72-78

Li, J.; Wang, L.; Zou, Y. and Li, J. (2022). Spatial variation of diatom diversity with water depth at Huguang Maar Lake, Southern China. *Journal of Paleolimnology*, *68*(1), 1–13. https://doi.org/10.1007/s10933-021-00218-5

Madhankumar, M. and Venkatachalapathy, R. (2023). A biological diatom indices-based preliminary assessment of water quality of Thamirabarani river, Southern India. *International Journal of Environmental Analytical Chemistry*, *9*, 1–13. https://doi.org/10.1080/03067319.2023.2230136

Mesquita, A.F.; Jesus, F.; Goncalves, F.J.M. and Goncalves, A.M.M. (2023). Ecotoxicological and biochemical effects of a binary mixture of pesticides on the marine diatom *Thalassiosira weissflogii* in a scenario of global warming. Science of the Total Environment, 876, 162737

Mesquita, M.C.B.; Prestes, A.C.C.; Gomes, A.M.A. and Marinho, M.M. (2020). Direct Effects of Temperature on Growth of Different Tropical Phytoplankton Species. *Microbial Ecology*, *79*(1): 1–11. https://doi.org/10.1007/s00248-019-01384-w

Odum, O. (1971). Fundamental of ecology. *Journal of Animal Ecology*, *3*(2).

Petrov, A.N. and Nevrova, E.L. (2020). Estimation of cell distribution heterogeneity at toxicological experiments with clonal cultures of benthic diatoms. *Marine Biological Journal*, *5*(2). https://doi.org/10.21072/MBJ.2020.05.2.07

Poulíčková, A.; Dvořák, P.; Mazalová, P. and Hašler, P. (2014). Epipelic microphototrophs: an overlooked assemblage in lake ecosystems. Freshwater Science, 33(2):513-523. doi: 10.1086/676313

Prasiska, Y.; Thamrin, T. and Siregar, S.H. (2020). The Diversity and Abundance of Planktonic Diatoms Vertically in Nareh Coastal Waters Manggung Village North Pariaman Sub-District Pariaman City West Sumatera Province. *Journal of Coastal and Ocean Sciences*, *1*(1): 60-67. https://doi.org/10.31258/jocos.1.1.60-67

Shaimaa, A.F.; Reidh A.A.J. and Fikrat M.H. (2023). Qualitative and Quantitative study of Epipelic diatoms in Tigris River within Wasit province, Iraq. *Tikrit Journal* *of Pure Science*, *23*(6), 48–56. https://doi.org/10.25130/tjps.v23i6.671

Shang, Z.W.; Li, J.F.; Freund, H.; Shi, P.X and Wang, H. (2023). Quantitative relationship between surface sedimentary diatoms and water depth in North-Central Bohai Bay, China. *China Geology*, *6*(1). https://doi.org/10.31035/cg2022040

Sharma, S.; Shukla, K.; Mishra, A.; Vishwakarma, K. and Shukla, S. (2023). *Diatoms: A Potential for Assessing River Health*. Insights into the World of Diatoms: From Essentials to Applications (pp.121-130). https://doi.org/10.1007/978-981-19-5920-2_7

Stenger-Kovács, C.; Béres, V.B.; Buczkó, K.; Al-Imari, J.T.; Lázár, D.; Padisák, J. and Lengyel, E. (2023). Review of phenotypic response of diatoms to salinization with biotechnological relevance. *Hydrobiologia*, 850(20). https://doi.org/10.1007/s10750-023-05194-7

Stoof-Leichsenring, K.R.; Dulias, K.; Biskaborn, B.K.; Pestryakova, L.A.; and Herzschuh, U. (2020). Lake-depth related pattern of genetic and morphological diatom diversity in boreal Lake Bolshoe Toko, Eastern Siberia. *PLoS ONE*, *15*(4). https://doi.org/10.1371/journal.pone.0230284

Supono, S. and Hudaidah, S. (2018). Short communication: The diversity of epipelic diatoms as an indicator of shrimp pond environmental quality in Lampung Province, Indonesia. *Biodiversitas*, *19*(4): 1220–1226. https://doi.org/10.13057/biodiv/d190406

Tampubolon, T.; Nurrachmi, I. and Nedi, S. (2020). Analysis of Nitrate, Phosphate and Concentration Ability of Diatom (Bacillariophyta) Planktonik in the Sumatera Province of West Nirwana Beach. *Asian Journal of Aquatic Sciences*, *2*(1): 21–28. https://doi.org/10.31258/ajoas.2.1.21-28

Thacker, M. and Karthick, B. (2024). A catalogue of Quaternary diatoms from the Asian tropics with their environmental indication potential for paleolimnological applications. 311-391. doi: 10.1016/b978-0-323-99519-1.00012-0

Wang, Q.; Yang, X.; Hamilton, P.B. and Zhang, E. (2012). Linking spatial distributions of sediment diatom assemblages with hydrological depth profiles in a plateau deep-water lake system of subtropical China. *Fottea*, *12*(1): 59–73. https://doi.org/10.5507/fot.2012.005

Wang, Y.; Wu, N.; Tang, T.; Wang, Y. and Cai, Q. (2022). Small run-of-river hydropower dams and associated water regulation filter benthic diatom traits and affect functional diversity. *Science of the Total Environment*, *813*(1). https://doi.org/10.1016/j.scitotenv.2021.152566

Wasmund, N.; Kownacka, J.; Göbel, J.; Jaanus, A.; Johansen, M.; Jurgensone, I.; Lehtinen, S. and Powilleit, M. (2017). The diatom/dinoflagellate index as an indicator of ecosystem changes in the Baltic Sea 1. Principle and handling instruction. *Frontiers in Marine Science*, *4*(FEB). https://doi.org/10.3389/FMARS.2017.00022

Xu, S.; Liu, Y.; Zhang, Z.; Xu, Y. and Qi, Z. (2022). Distributional Pattern of Bacteria, Protists, and Diatoms in Ocean according to Water Depth in the Northern South China Sea. *Microbiology Spectrum*, *10*(6). https://doi.org/10.1128/spectrum.02759-21

Zareh, M.M.; Metwally, N. and Abdel-Tawwab, M. (2023). The Lead Removal from Industrial Wastewater Using Two-Stages Poly-Urethane Column for Further Use in Aquaculture. *Egyptian Journal of Aquatic Biology and Fisheries*, *27*(4). https://doi.org/10.21608/ejabf.2023.307030