Diversity of Epipelic Diatom in The Waters of Tanjung Pinang City Province of Riau Islands

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Abstract. Degradation indicator of water quality can be seen from changes in water quality parameters. Diatoms are one organism that can be used as an environmental bioindicator. Diatoms are the primary producers in waters so they have a very important role in the food chain. Data was collected in situ in the Tanjung Unggat waters of Tanjung Pinang City. The method used in this study is a survey method, where data is obtained through observations and measurements in the field. The samples taken are then taken to the laboratory for analysis. Epiphyte diatom samples were taken from 4 stations with different activities. Based on observations of the identification of diatom epipelic that has been done, found 22 diatom genera, namely, Pleurosigma sp., Navicula sp., Diploneis sp., Achnanthes sp., Synedra sp., Nitzschia sp., Gyrosigma sp., Surirella sp., Coscinodiscus sp., Thallasiossira sp., Thallasionema sp., Pinnularia sp., Plagiotropis sp., Halamphora sp., Biddulphia sp., Melosira sp., Chaetoceros sp., Triceratium sp., Isthmia sp., Licmopora sp., and Rhizosolenia sp. The abundance of diatoms in epipelic samples, which ranged from 905277 - 599530 ind / cm². The structure of Epipelic Diatom Community average diversity index ranges from 3.72 to 4.65 and the dominance index value ranges from 1.09 to 1.46 and the uniformity index value ranges from 0.95 to 1.21. Then based on the results of the Storet Index classification, getting a score of -52.75 on 8 parameters tested. This scoring means that around the category of Class D Tanjung Pinang Coastal waters with a score ≥ -31 are classified as Heavy Polluted waters with the determination of the status of the waters quality is limited to 8 parameters tested.

1. Introduction
Tanjung Pinang City is the capital of the Riau Islands Province, as a center of trade and services, industry, tourism and a cultural center of Malay. Tanjung Unggat waters is one of the coastal waters in Tanjung Pinang City. Tanjung Unggat waters are areas of ship traffic and some settlements are located on the coast. The number of activities in the area is thought to be able to disrupt the balance of the ecosystem in these waters which has an impact on changes in physics, chemistry and biology. In addition there is a mangrove ecosystem in this water area as a supplier of nutrients to the waters.

Changes in the quality of the aquatic environment can also be seen from biological indicators such as seeing the existence of organisms, both individual, populations or communities. One of the organisms in question is diatoms. Diatoms are one of the organisms that can be used as environmental bioindicators whereas the existence of diatoms is influenced by various factors such as waters quality and the substrate condition where they attach. Therefore, diatoms have a good response to the effects of pollution [1].

Based on this description, it is necessary to conduct research on "Diversity of Epipelic Diatom in Tanjung Unggat Waters of Tanjung Pinang City Province of Riau Islands".
2. Material and Method

2.1 Time and Place
This research was conducted in July-August 2019, in Tanjung Unggat waters, Tanjung Pinang City. The sampling area consisted of 4 stations namely station 1 located in the loading and unloading area, station 2 in the Muara Sungai Payung area, station 3 in a dense residential area, and station 4 in an area with minimal human activity, as shown in Figure 1. Analysis of parameters biology (community structure and abundance of diatoms) and physical, chemical parameters were carried out at the Laboratory of Marine Biology and the Laboratory of Oceanographic Chemistry, Department of Marine Sciences, Faculty of Fisheries and Marine Science, Riau University.

![Figure 1. Map of research location and sampling stations](image)

2.2 Research methods
Location of sampling physical and chemical biological parameters (diatoms) is determined by purposive sampling. Data obtained from sampling are presented in tables and graphs discussed descriptively related to water quality. Whereas the diatom abundance, diversity index, uniformity index and dominance index are calculated using computer applications. Statistical calculations are carried out, namely the Storet index to measure the quality of contamination of a water body by using comparison data between water quality data and water quality standards adjusted for their designation.

2.3 Diatom Sampling
Sampling of epipelic diatom was carried out at 4 stations with 3 sampling points in each station, between 10:00 to 13:00 WIB. Diatom sampling is done by scraping sediments as deep as 0.5 cm in plots measuring 5 x 5 cm² at low tide. Then, the samples were entered into a sample bottle and added with distilled water until it reaches 100 ml. Samples are preserved with 4% lugol as much as 3-4 drops, then the sample vials are labeled according to the sampling code and stored in an ice box for further analysis in the laboratory.

2.4 Diatom sample observation
Diatom observations were carried out using an Olympus CX 21 binocular microscope with a magnification of 10 × 10, whereas for identification it used a magnification of 10 × 100. Observations used the visual field method by one observation of 12 fields. Samples observation were conducted for three times for each sample. Before being observed, the
A diatom water sample was stirred so that the diatoms are spread evenly and have the same chance to be taken. The diatoms observed were identified using the books [2], [3] and the website of Diatom org.

2.5. Diatom Abundance
Epiphyte diatom abundance was calculated using the modified Lackey Drop Microtransecting Methods based formula [4]:

\[ N = \frac{3O_i}{Op} \times \frac{Vr}{3Vo} \times \frac{1}{A} \times \frac{n}{3p} \]

Description:
- \( N \): Number of epipelic diatoms per unit area (individual/cm\(^2\))
- \( O_i \): Area of the glass cover (25 x 25 mm = 625 mm\(^2\))
- \( Op \): View area of Olympus CX 21 microscope with magnification of 10x10 (1,306 mm\(^2\))
- \( Vr \): Volume of sample water in a sample bottle (100 ml)
- \( Vo \): Volume of 1 sample drop (0.06 ml)
- \( A \): Size of the scrap area (5 cm\(^2\))
- \( n \): Number of epipelic diatom enumerated
- \( P \): Number of field of view (12)

2.6. Storet Index
The storet index is used to determine the status of water quality based on The Minister of Environment Regulation No. 51 of 2004 concerning Water Quality Management and Water Pollution Control [5]. How to determine the status of water quality is to use a value system from [6] by classifying water quality in 4 classes, namely:
1. Class A: Very good, score = 0 = meets quality standards
2. Class B: Good, score = -1 to -10 = lightly polluted
3. Class C: Moderate, score = -11 to -30 = moderately polluted
4. Class D: Bad, score > -31 = heavily polluted

2.7. Analysis Species diversity index \( (H') \)
Species diversity index analysis is used to see the diversity of diatoms, use the Shannon-Winner formula as follows [7]:

\[ H' = -\sum_{i=1}^{s} p_i \log_2 p_i \]

Description:
- \( \log_2 \): 3.3219
- \( H' \): Index of species diversity
- \( p_i \): Proportion of individuals of the i-th species to total individuals All species \( (p_i = \frac{n_i}{N}) \)
- \( n_i \): total number of individuals of the i-th type (individual / cm\(^2\))
- \( N \): total individuals of all types (individual / cm\(^2\))
- \( S \): Number of all individuals
Criteria:
\[ H' < 1 \Rightarrow \text{Biota community is not balanced or water quality is heavily polluted} \]
\[ 1 \leq H' \leq 3 \Rightarrow \text{Balance of moderate biota community, and moderate polluted water quality.} \]
\[ H' > 3 \Rightarrow \text{Biota balance in prime condition and clean water quality.} \]

2.8. Analysis Dominance Index (D)
Dominance index analysis is used to calculate the diatom dominance index using the Simpson formula as follows [7]:

\[ D = \sum_{i=1}^{n} \left( \frac{n_i}{N} \right)^2 \]

Description:
ni = total number of individuals of the i-th type (individual / cm\(^2\))
N = total individuals of all types (individual / cm\(^2\))

Criteria:
D approaches 0 (<0.5) = There is no dominant type
D approaches 1 (>0.5) = There are species that dominate

2.9. Analysis of Species Uniformity Index (E)
Analysis of species uniformity index is used to see the uniformity of diatom organisms in a balanced state or not, which is calculated using the formula Pilou as follows [8]:

\[ E = \frac{H'}{\log_2 S} \]

Description:
E = index of species uniformity
H' = Index of species diversity
S = Number of species encountered

Criteria if the value of E:
- Approaching 1 (> 0.5) means uniformity of organisms in a balanced state and there is no competition either against certain places or food.
- Near zero (<0.5) means that the uniformity of organisms in the waters is unbalanced and food competition occurs.

3. Results and Discussion
3.1. Condition of the study area
Tanjung Pinang City is located on Bintan Island, located at position 00 50' to 00 59 North Latitude and 1040 23' to 1040 34 East Longitude. The area of Tanjung Pinang City is 258.82 km\(^2\) which consists of 150.86 km\(^2\) land area and 107.96 km\(^2\). Tanjung Pinang City is directly adjacent to Bintan Regency, which is to the north: Teluk Bintan District, Bintan Regency; south: Mantang District, Bintan Regency; west: Pangkil Village, Teluk Bintan District, Bintan Regency and east: Kec. East Bintan and Kec. Toa Paya, Bintan Regency. The waters around Tanjung Pinang are waters that have been used by the community as a source of income from the catches of fish, shrimp, crabs, and other economic biota. But besides that, in the Tanjung Pinang area there are also a number of bauxite mining activities, shipyards, loading and unloading ports, settlements, and reclamation of mangrove land for development.
3.2. Water Quality Measurement

The observed water quality parameters include water physics and chemical chemistry parameters. Water physics parameters consist of temperature, brightness and current speed. While the water chemical parameters consist of pH, salinity and BOD, COD nitrate and phosphate. For more detailed data on the parameters of water physics can be seen in Tables 1 and 2.

Table 1. Average Value of Aquatic Physics-Chemical Parameters

| Parameters         | Station | | | | | | | |
|--------------------|---------|---|---|---|---|---|---|---|---|
|                    | 1       | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| **Sub station**    | | | | | | | | | |
| **Physics**        | | | | | | | | | |
| Temperature (°C)   | 30      | 30.7 | 30.1 | 31.9 | 31.7 | 32.2 | 34.1 | 32.7 | 33.5 |
| Visibility (Cm)    | 110     | 125  | 107.5 | 95   | 45   | 60   | 60   | 75   | 60   |
| Current speed (m/second) | 7.8  | 7.5  | 5.3  | 7.3  | 5.1  | 8.0  | 4.0  | 4.2  | 4.2  |
| **Chemical**       | | | | | | | | | |
| pH                 | 6.4     | 7.2  | 7.2  | 7.4  | 7.3  | 7.4  | 7.8  | 7.7  | 7.7  |
| Salinity (ppt)     | 33      | 26   | 30   | 28   | 31   | 26   | 26   | 25   | 23   |
| BOD₃ (mg/l)        | 18      | 20   | 20.2 | 20.4 | 20.2 | 20.6 | 21   | 20.8 | 20.4 |
| COD (mg/l)         | 120     | 96   | 88   | 112  | 88   | 96   | 136  | 128  | 136  |
| Nitrate (mg/l)     | 0.02    | 0.03 | 0.03 | 0.04 | 0.05 | 0.04 | 0.03 | 0.02 | 0.02 |
| Phosphate (mg/l)   | 0.01    | 0.02 | 0.03 | 0.03 | 0.04 | 0.02 | 0.02 | 0.02 | 0.01 |

Based on the data in Table 1 that the temperature range in Tanjung Pinang waters is 30-35.2°C, in general the results of temperature measurements are still suitable for the growth and development of Diatoms. Diatoms will grow well in a consecutive temperature range of 20 ± 30°C-30 ± 35°C, due to the absorption of solar heat entering the body of water by suspended and dissolved particles, both from industrial waste and from domestic.

The results of the measurement of the level of brightness in the waters of Tanjung Pinang obtained an average value of brightness ranging from 45-125 cm, based on the results of the measurement of brightness at stations 2, 3 and 4 show a lower value when compared to station 1. This is understandable because the location of this station is closer to the harbor and residential areas with more turbulent waters which attack sediment particles from the bottom to surface waters.
A strong current velocity can reduce the type of living organism so that only the inherent species survive with the current. The average value of current speed in the waters of Tanjung Pinang was 0.08-0.14 m / sec and it was classified as very weak to moderate. Stated that current speed less than 0.1 m / s, including very weak current speeds, while 0.1-1.0 m / s are classified as medium current speeds, current velocity> 1 m / sec is classified as a strong current speed [9].

3.3. Composition of Epipelic Diatoms
Following are the epipelic diatom compositions found at all stations during the study presented in Table 2.

Table 2. Composition of Epipelic Diatoms in Tanjung Pinang Waters

| No | Species               | 1.1 | 1.2 | 1.3 | 2.1 | 2.2 | 2.3 | 3.1 | 3.2 | 3.3 | 4.1 | 4.2 | 4.3 |
|----|-----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1. | Pleurosigma sp.       | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 2. | Navicula sp.          | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 3. | Diploneis sp.         | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 4. | Achnanthes sp.        | +   | +   | +   | +   | +   | +   | -   | -   | -   | +   | +   | +   |
| 5. | Synedra sp.           | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 6. | Nitzschia sp.         | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 7. | Gyrosigma sp.         | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 8. | Sarirella sp.         | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 9. | Cosinodiscus sp.      | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 10. | Thalassiosira sp.     | +   | -   | -   | +   | -   | -   | -   | -   | -   | +   | +   | +   |
| 11. | Thalassionema sp.     | +   | -   | -   | +   | +   | +   | -   | +   | -   | +   | +   | +   |
| 12. | Pinnularia sp.        | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 13. | Plagiotropis sp.      | +   | +   | +   | +   | +   | -   | +   | +   | +   | +   | +   | +   |
| 14. | Halamphora sp.        | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   |
| 15. | Biddulphia sp.        | +   | -   | +   | -   | -   | -   | -   | -   | -   | -   | -   | -   |
| 16. | Melosira sp.          | -   | +   | +   | +   | +   | -   | -   | -   | -   | -   | -   | -   |
| 17. | Chaetoceros sp.       | -   | -   | +   | -   | -   | -   | -   | -   | -   | -   | -   | -   |
| 18. | Triceratium sp.       | -   | +   | -   | -   | -   | -   | -   | -   | -   | +   | +   | +   |
| 19. | Isthmia sp.           | -   | -   | -   | -   | +   | +   | -   | +   | +   | +   | +   | +   |
| 20. | Licmopora sp.         | -   | -   | +   | -   | -   | -   | -   | -   | -   | -   | -   | -   |
| 21. | Rhizosolenia sp.      | -   | -   | -   | -   | +   | -   | +   | -   | -   | -   | -   | -   |

Total number of species: 15 14 17 16 15 15 12 11 15 13 15

Description: +: Found
- : Not found

States that diatoms have different responses to water conditions so that the species varies in various places. Based on observations and identification, 21 species were found, namely Pleurosigma sp., Navicula sp., Diploneis sp., Achnanthes sp., Synedra sp., Nitzschia sp., Gyrosigma sp., Sarirella sp., Cosinodiscus sp., Thalassiosira sp., Thalassionema sp., Pinnularia sp., Plagiotropis sp., Halamphora sp., Biddulphia sp., Melosira sp., Chaetoceros sp., Triceratium sp., Isthmia sp., Licmopora sp., and Rhizosolenia sp. Diatoms have weak
mobility so that their distribution will be greatly influenced by the movement of surface currents [10].

3.4. Abundance of Epipelic Diatoms
Following are the epipelic diatom abundances found at all stations during the study presented in Table 3.

| Point | Station | Number of Individual | Abundance | Average |
|-------|---------|----------------------|-----------|---------|
| 1.1   | 1       | 535                  | 711194    |         |
| 1.2   |         | 604                  | 802918    | 905277  |
| 1.3   |         | 904                  | 1201719   |         |
| 2.1   | 2       | 712                  | 946486    |         |
| 2.2   |         | 348                  | 462608    | 569841  |
| 2.3   |         | 226                  | 300430    |         |
| 3.1   | 3       | 168                  | 223328    |         |
| 3.2   |         | 957                  | 1272173   | 601302  |
| 3.3   |         | 232                  | 308406    |         |
| 4.1   | 4       | 552                  | 733793    |         |
| 4.2   |         | 486                  | 646057    | 599530  |
| 4.3   |         | 315                  | 418740    |         |

Based on Table 3, the abundance of Epipelic diatoms found can be obtained the average value of epipelic diatom abundance in waters with different abundance values at each observation station. Where the abundance values range from 569841 to 905277 individual/cm². For more details, can be seen in Figure 2.

![Epipelic](image)

**Figure 2. Abundance of Epipelic Diatoms**
Based on Figure 2, the average value of epipelic diatom abundance in the highest waters is at station 2 with a value of 905277 ind / cm², while the lowest is at station 1 with a value of 569,841 ind / cm².

3.5. Diatom Community Structure

The value of species diversity index, dominance index value and planktonic species uniformity index value can be seen in Table 4.

Table 4. Structure of Epipelic Diatom Community

| St | Sub station | Diversity Index (H') | Average (H') | Dominance Index (D) | Average (D) | Uniformity Index (E) | Average (E) |
|----|-------------|----------------------|-------------|---------------------|-------------|---------------------|-------------|
| 1  | 1.1         | 3.70                 | 2.49        | 1.06                | 0.95        |
|    | 1.2         | 4.02                 | 3.72        | 1.46                | 0.98        |
|    | 1.3         | 3.43                 | 0.32        | 0.82                | 0.95        |
| 2  | 2.1         | 3.27                 | 1.89        | 1.06                | 0.98        |
|    | 2.2         | 4.16                 | 0.98        | 1.09                | 0.98        |
|    | 2.3         | 4.08                 | 0.40        | 1.05                | 0.98        |
| 3  | 3.1         | 4.38                 | 0.35        | 1.15                | 1.04        |
|    | 3.2         | 3.25                 | 1.40        | 1.36                | 0.91        |
|    | 3.3         | 3.64                 | 2.33        | 1.05                | 1.21        |
| 4  | 4.1         | 4.63                 | 1.46        | 1.19                | 1.04        |
|    | 4.2         | 4.04                 | 0.84        | 1.09                | 1.21        |
|    | 4.3         | 5.28                 | 1.13        | 1.35                | 1.21        |

Based on Table 4, the epipelic diatom community structure can be obtained a different average value at each research station. The community structure value consists of the biological index values as follows: diversity index, dominance index and uniformity index. Following the average value of the diversity index ranges from 3.72 to 4.65 and the value of the dominance index ranges from 1.09 to 1.46 and the uniformity index value ranges from 0.95 to 1.21, for more detailed biological index values can be seen in Figure 3.

Figure 3. Histogram of Epiphyte Diatom Biological Index
Based on Figure 3, the average values of different biological indices are obtained. The average value of the epipelic diatom diversity index ranges from 3.72 to 4.65, if it is adjusted to the value of the Shannon Winner diversity index, with a range of $H$ diversity index values showing the diversity value at each research station classified as biota balance high and light polluted waters quality [7]. The value of diversity with a range > 3 indicates that the waters in the condition of polluted waters are low [11]. The average value of epipelic diatom dominance index ranges from 1.09 to 1.46 where, based on the Simpson dominance index determination with a range of dominance index values close to 1 (> 0.5), there are species that dominate at each station [7]. The dominance index in waters close to 1 indicates that the community structure is generally stable and there is no ecological pressure on the biota in these waters [12].

The average uniformity index of epipelic diatom ranges from 0.95 to 1.21, when seen from the Pilou uniformity index with a range of uniformity index values close to 1 (> 0.5) indicating the uniformity value at each research station classified as uniformity organisms in a balanced state and there is no competition either against certain places or food [8]. A uniformity index close to zero tends to indicate an unstable community, whereas when approaching one, the community is in a stable state, the number of individuals between species is the same.

3.6. Storet Index

The Storet Index is one of the instruments to measure the quality of contamination of a water body by using comparative data between water quality data and water quality standards adjusted for their purpose. The results of storet calculations based on physical and chemical parameters can be seen in Table 5.

| No | Parameter | Sub Parameter | Skor |
|----|-----------|---------------|------|
| 1  | Physic    | Temperature   | -2.75|
| 2  |           | Visibility    | -5   |
| 3  |           | Current speed | -2   |
| 1  | Chemical  | Ph            | -8   |
| 2  |           | BOD           | -10  |
| 3  |           | COD           | -5   |
| 4  |           | Phosphate     | -10  |
| 5  |           | Nitrate       | -10  |
|    | Score     |               | -52.75|

Based on Table 5, the results of measurements of the quality of the waters around Tanjung Pinang Coastal waters according to the Storet Index show that the Storet Index scores are -52.75. Based on the classification of the Storet Index, this scoring means that around the category of Class D Tanjung Pinang Coastal waters with a score of ≥ -31 are classified as Heavy Polluted waters with determination of the status of the waters quality is limited to 8 parameters tested.
4. Conclusion

Epiphyte diatoms found in Tanjung Pinang Coastal waters based on the results of observations identified that have been made there are 22 genera found with the quality of waters in Tanjung Pinang classified as good. Epipitic diatom abundance ranged from 569,841 - 905,277 cell/cm². The structure of epipelagic diatom community has a diversity index ranging from 3.72 to 4.65 and a dominance index value ranging from 1.09 to 1.46 and a uniformity index value ranging from 0.95 to 1.21. The Storet Index Classification, this scoring means that around the category of Class D Tanjung Pinang Coastal waters with a score ≥ -31 are classified as Heavy Polluted waters with determination of water quality status limited to 8 parameters tested.

5. Suggestion

Further research is needed with a higher number of observation points in order to obtain more reflective species data that will be used as key species in each substrate examined at the Tanjung Pinang City research site.

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