Diversity of Planktonik Diatom at Bengkalis Waters, Riau Province

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Abstract. This research was carried out in August to September 2019 at Bengkalis Waters, Riau Province. This study goals to describe the water quality statuses and to determine the species composition, abundance and biological index of planktonic diatom in the Bengkalis waters. Survey method was applied in this research which are 5 stations established, with 3 sampling points in each station. The stations were determined purposively based on anthropogenic activities conducted in that area. Diatom samples were filtered from surface water as much as 100 liters by using plankton net number 25, and the samples were then observed using an Olympus CX 21 microscope (magnification 10 x 10 and 10 x 40) and were identified. The value of water quality at each station indicates that the water is in normal range and it may support the growth of diatoms. There were 20 species of planktonic diatoms recorded in the Bengkalis waters. There were 2 species, namely Coscinodiscus sp. and Navicula sp. that were found in each station. Meanwhile, the abundance of planktonic diatoms ranged from 23,041.80 to 286,693.18 ind / l. The average of biological indices values are as follows: diversity index 1.39-2.32, dominance index 0.24 to 0.48 ind / l, and the uniformity index 0.55 to 0.87 ind / l. The biological indices values indicated that the Bengkalis Waters can be categorized as moderate polluted water and there is no dominant species.

1. Introduction
Bengkalis Regency is one of the areas that are directly related to the Malacca Strait. In these recent years there have been developments in various sectors such us housing, transportation and industry. As a marine transportation route, the Bengkalis waters may receive waste material from the ships and it may negatively affect the waters. Changes of waters quality in aquatic environment can be shown from biological indicators. Besides that, the environmental changes will also change the existence of organisms, in individual, population or community.
One of organisms that has a rapid response to changes in water quality is phytoplankton, especially the class Bacilliriophycea (planktonic diatoms). Baccillariophycae are one of organisms that can be applied as a tool of environmental bioindicators [1]. The presence of planktonic diatoms in the water column are influenced by water quality and these organisms have a good response to the effects of pollution. This organism has very fast response to environmental changes, and they have short life cycle period compared to other organisms, including fish and micro invertebrates [2]. Planktonic diatoms are primary producers their role is very important in the food chain. This organism also able to reproduce quickly and able to reflect changes in the water quality because they are sensitive to environmental changes. Thus, research on the diversity of planktonic diatoms in relation to changes in water quality is very important to describe the condition of Bengkalis waters.

2. Methodology
2.1 Time and place
This research was carried out in August to September 2019 at Bengkalis Waters. Sampling area were divided into five stations purposively, station 1 at Perapat Tunggal Beach (01° 33'55" LU 102 ° 10" BT), station 2 at Simpang Ayam Beach (01 ° 36'14.45" LU 102 ° 03 ' 39.96 "BT), station 3 at Muara Sungai Perapat Tunggal (01 ° 33'28.75" LU 102 ° 01'30.40 "East), station 4 at Roro Bengkalis Port (01°27'01.22" LU 102 ° 08'14.68 "BT), and station 5 at the Port of Roro Sei Pakning (01 ° 22'39.40" LU 102 ° 08'55.31 "East), as seen in Figure 1. Further, sample of planktonic diatoms and water quality are analysis at Marine Biology and Oceanographic Chemistry Laboaratory, of Marine Sciences Department, Fisheries and Marine Faculty, Riau University.

Figure 1. Map of Bengkalis Waters as Research Location with Five Stations
2.2. Research Methods
The survey methods were applied in this research whereas sampling stations is determined purposively based on antrophogenic sources. Data of water quality and diatoms are shown in tables and graphs and then they are discussed descriptively. Computer applications are used to calculate diatom abundance and biological index value (diversity index, uniformity index and dominance index).

2.3. Planktonic Diatom Sampling
Sampels of diatom was undertaked between 10am to 3pm western Indonesia time in each 5 station. Afterwards diatom samples were collected by filtering100 liters of surface water using plankton net number 25 into 100 ml. The samples were kept in the dark colored bottle and were preserved using 4% lugol (3-4 drops/ bottle). All of samples were kept in ice box for further analysis in the laboratory.

2.4. Identification and Observation Diatom Samples
Identification and observation diatom samples were observed using an Olympus CX 21 binocular microscope with 10×10 magnification, detail caracteristics were investigated using 10×100 magnification. The samples were shake gently and a drop of sample was spread in the objeck glass. To count the number of diatoms, a visual field technique was applied, with 12 fields and 3 replications for each sample. The diatoms observed were identified using the identification books of [3,4].

2.5. Diatom Abundance Calculation
Planktonic abundance is calculated based on Lakey Drop Macrotransec Counting (LDMC) formula [5]:

\[
\text{ind/liter} = \frac{T}{L} \times \frac{Vo}{Vo} \times \frac{1}{1} \times \frac{1}{p} \times \frac{1}{W} \times N
\]

Description:
N = Diatom abundance
T = Cover / glass area (625 mm²)
L = Microscope Field Area (1,306 mm²)
Vo = Volume of Sample after filtering (100 ml)
V1 = Volume of Sample under glass cover (0.01 ml)
p = Number of field view observed (12)
W = volume of filtered water (100 liters)

2.6. Calculation of Diversity Index (H')
The Shannon-Winner formulation is applied to calculated diversity of planktonic diatoms as follows [6]:

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

Description:
\[ \log_2 = 3.3219 \]

\( H' \) = Index of species diversity

\( \frac{ni}{N} \) = Proportion of individuals of the i-th species to total individuals of all species

\( ni \) = Total number of cells of the i-th species (cell/l)

\( N \) = Total number of species number (cell/l)

\( s \) = Number of total individuals

With criteria:

\( H' < 1 \) = Biota community is unbalance or water quality is classified to heavily polluted

\( 1 \leq H' \leq 3 \) = Biota community is relatively balance and water quality is classified to moderate polluted.

\( H' > 3 \) = Biota community is balance and water quality is classified to clean water

2.7. Dominance Index (D)

Simpson formulation is used to calculate the diatom dominance index as follows [6]:

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

Description:

\( ni \) = Total number of individuals of the i-th type (cell/l)

\( N \) = Total number of all types (cell/l)

With criteria:

D approaches 0 (<0.5) = There is no dominant species

D approaches 1 (>0.5) = There are dominant species

2.8. Uniformity Index (E)

The uniformity of planktonic diatom was calculated according to Pilou formulation as follows [7]:

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

Description:

E = index of species uniformity

\( H' \) = Index of species diversity

S = Number of species encountered

The E value criteria:

- Approaching 1 (>0.5) means uniformity of the organism in a balanced state and there is no competition either against certain places or food.

- Approaching zero (<0.5) means that the uniformity of organisms in water is unbalanced and food competition occurs.

3. Results and Discussion

3.1. Water Quality Measurement

The physical and chemical chemical of water quality parameters were measured. The physical parameters including temperature, brightness and current speed. While chemical parameters including pH, salinity and BOD, COD nitrate and phosphate. Data on the water quality parameters are presented in Tables 1 and 2.
Table 1. Physical Parameter Values

| Stations | Temperature (°C) | Visibility (m) | Current Speed (m/det) |
|----------|------------------|----------------|-----------------------|
| 1        | 28,5             | 0,4            | 0,40                  |
| 2        | 31,0             | 0,13           | 0,27                  |
| 3        | 32,1             | 0,47           | 0,20                  |
| 4        | 32,0             | 0,56           | 0,3                   |
| 5        | 32,9             | 0,61           | 0,3                   |

Table 2. Chemical Parameter Values

| Stations | pH  | Sal (%) | BOD (mg/l) | COD (mg/l) | Nitrate (mg/l) | Phosphate (mg/l) |
|----------|-----|---------|------------|------------|----------------|------------------|
| 1        | 7.2 | 27      | 21.1       | 63.1       | 0.04           | 0.065            |
| 2        | 7.3 | 26      | 21.0       | 64.3       | 0.04           | 0.034            |
| 3        | 7.4 | 24      | 21.0       | 61.8       | 0.06           | 0.066            |
| 4        | 7.2 | 27      | 20.7       | 61.0       | 0.04           | 0.037            |
| 5        | 6.5 | 26      | 20.2       | 61.8       | 0.02           | 0.019            |

Data presented in Table 1 and 2 shown that the value of water quality parameters were in optimal range for supporting aquatic organism life. The average value of phosphate concentration is 0.044 mg/l and nitrate concentration is 0.038 mg / l at Bengkalis waters is similar to obtained at the Cawan Island waters [8], where the phosphate concentrations was higher than that of nitrate concentration, which is 0.1342 to 0.2345 mg/l (phosphate) and 0.0139 to 0.0639 mg/l (nitrate). Furthermore, Maslukah (2014) stated that the variations in nitrate and phosphate concentrations in waters are influenced by the amount of fresh water flowed and the resuspension process. The existence of fresh water flow and resuspension process causes the concentration of nutrients in the waters became higher.

The fertility level of waters based on nitrate content can be divided into three levels, namely 0.0 - 0.1 ppm (oligotrophic or less fertile) waters, 0.1 - 0.5 ppm (mesotrophic or moderate fertility) and more than 0.5 ppm (eutrophic waters or high fertility) [9]. Based on the nitrate concentration value, the Bengkalis waters can be categorized as medium fertility waters (mesotrophic). The BOD concentrations in all sampling areas have exceeded the water quality standard issued (20 mg / l) [10]. Large BOD values may not support the live of aquatic organisms. Natural waters that are suitable for fishery activities should have a 0.5-7.0 mg / l BOD content, while waters with a BOD value more than 10 mg / l are considered as polluted [9]. BOD is the need for oxygen for a number of bacteria to decompose all dissolved organic substances and as suspended in water into simpler organic matter [11]. The active bacteria decompose organic matter along with the depletion of oxygen consumed. The depletion of oxygen consumed makes the biota deficient in oxygen and unable to live. Based on water quality standards in Government Regulation No. 82 of 2001, a maximum allowable COD value of 50 mg / l. The COD content at stations I, II, III, IV, and V has exceeded the permitted quality standard. Based on these data, it can be predicted that the water is in polluted conditions. COD concentrations will increase with the increasing amount of organic matter found in the waters. High concentrations of BOD and COD in the water negatively affect the
plankton and causes low plankton diversity [12].

3.2. Planktonic Diatom Composition
The composition of the planktonic diatoms found at all stations during the study are presented in Table 3.

| No | Species                  | Stations |
|----|--------------------------|----------|
| 1  | *Isthmia* sp.            | v        |
| 2  | *Coscinodiscus* sp.      | v        |
| 3  | *Biddulphia* sp.         | v        |
| 4  | *Pleurosigma* sp.        | v        |
| 5  | *Melosira* sp.           | v        |
| 6  | *Amphora* sp.            | v        |
| 7  | *Navicula* sp.           | v        |
| 8  | *Diploines* sp.          | -        |
| 9  | *Plagiogramma* sp.       | -        |
| 10 | *Stephanodiscus* sp.     | -        |
| 11 | *Triceratium* sp.        | -        |
| 12 | *Nitzschia* sp.          | -        |
| 13 | *Rhizosolenia* sp.       | -        |
| 14 | *Synedra* sp.            | -        |
| 15 | *Surirella* sp.          | -        |
| 16 | *Bacillaria* sp.         | -        |
| 17 | *Halamphora* sp.         | -        |
| 18 | *Licmopra* sp.           | -        |
| 19 | *Pinnularia* sp.         | -        |
| 20 | *Achnantes* sp.          | -        |
|    | Total                    | 7 9 9 9 16 |

Table 3. Planktonic diatom compositions at Bengkalis Waters

| No | Species                  | Stations |
|----|--------------------------|----------|
|    |                          | 1 2 3 4 5 |

| No  | Species                  | Stations |
|-----|--------------------------|----------|
| 1   | *Isthmia* sp.            | v        |
| 2   | *Coscinodiscus* sp.      | v        |
| 3   | *Biddulphia* sp.         | v        |
| 4   | *Pleurosigma* sp.        | v        |
| 5   | *Melosira* sp.           | v        |
| 6   | *Amphora* sp.            | v        |
| 7   | *Navicula* sp.           | v        |
| 8   | *Diploines* sp.          | -        |
| 9   | *Plagiogramma* sp.       | -        |
| 10  | *Stephanodiscus* sp.     | -        |
| 11  | *Triceratium* sp.        | -        |
| 12  | *Nitzschia* sp.          | -        |
| 13  | *Rhizosolenia* sp.       | -        |
| 14  | *Synedra* sp.            | -        |
| 15  | *Surirella* sp.          | -        |
| 16  | *Bacillaria* sp.         | -        |
| 17  | *Halamphora* sp.         | -        |
| 18  | *Licmopra* sp.           | -        |
| 19  | *Pinnularia* sp.         | -        |
| 20  | *Achnantes* sp.          | -        |

Table 3. Planktonic diatom compositions at Bengkalis Waters

Data on Table 4 shown that the abundance of planktonic diatoms found in each station ranged from 41,209 – 286,693 cells/l. The lowest diatom planktonic abundance was found in station I (41,209 cells/l) and the highest was in station V (286,693 cell/l). The diatoms have different responses to water conditions and it may cause differences of diatom abundance in various places [9].

The highest abundance of planktonic diatoms was in the Station 5 that is located close to...
residential areas. The highness of the diatom abundance may be caused by community activities that are conducted in that area. There was amount of household waste that may discharged to the water and it may be increased the organic and inorganic materials input to the waters. The differences of diatom abundance might be caused by the differences of activities conducted around the sampling areas, as in each observation site there are different anthropogenic activities conducted [13]. The nutrient supply, however, affects the growth of diatoms in the waters.

The lowest abundance of diatom was in Station 1. The lowness of the diatom abundance may be caused by the influence of unfavorable water conditions that disturb the ecosystem as well as the phytoplankton present in that area. The parameters of salinity, nitrate have a major role in distinguishing the high and low abundance of phytoplankton [14]. The low nitrate and phosphate content at this station also affects the life processes of phytoplankton.

In this study, there were different diatom abundances in each research station. The abundance of planktonic diatoms are presented in Table 4.

| Stations | Abundance (Cell/l) |
|----------|-------------------|
| 1        | 41209             |
| 2        | 122298            |
| 3        | 23041             |
| 4        | 29688             |
| 5        | 286693            |

Data on Table 4 shown that the abundance of planktonic diatoms were different in each station. The abundance was ranged from 23041-286693 cell/l.

Figure 2 shown the planktonic diatom abundance in each station. The highest abundance was in station 5 with (286693 cell/l), while the lowest abundance was in station 3 (23041 cell/l).


3.4. Biological Indices

The value of species diversity index, dominance index value and uniformity index are presented in Table 5.

| Station | Diversity Index (H') | Biological Indices | Uniformity Index (E) |
|---------|----------------------|--------------------|----------------------|
| 1       | 1.44                 | 0.41               | 0.71                 |
| 2       | 1.39                 | 0.48               | 0.64                 |
| 3       | 2.06                 | 0.30               | 0.86                 |
| 4       | 2.32                 | 0.24               | 0.87                 |
| 5       | 1.89                 | 0.25               | 0.55                 |

Data on Table 5 shown that the planktonic diatom community structure obtained in each station was different. The average value of the Diversity Index was 1.39 to 2.32; dominance index was 0.24 to 0.48 and the uniformity index was 0.55 to 0.87. Data on biological indices value are presented in Figure 3.

Figure 3 shown the average value of biological indices studied. The highest diversity index value is in station 4 (2.32) and the lowest was in station 2 (1.39). The highest dominance index value was in station 2 (0.48) and the lowest was in station 4 (0.24). The highest uniformity index was in station 4 (0.87) and the lowest was in station 5 (0.55).

The average of planktonic diatom diversity index ranges from 1.39 to 2.32. The diversity index value  

\[ H^' \leq 3 \]

indicates that the H value in each research station can be classified as “a moderate biota balance” and “medium quality polluted waters” [6]. [15] Also, the value of diversity with a range of 1-2 indicates waters in moderate polluted waters.

The average value of planktonic diatom dominance index was ranged from 0.24 to 0.48. Based on the determination of Simpson's dominance index [6], the dominance index values that are close to 0 (<0.5) indicates that there is no species dominating in each station. According to [16], the dominance index...
index in the waters that is close to 0 indicates that the community structure is generally stable and there is no ecological pressure on the biota in these waters.

The average uniformity index of the planktonic diatoms ranged from 0.55 to 0.87. Based on Pilou uniformity index [7], the uniformity index values that is close to 1 (> 0.5) indicating that the uniformity values in each research station can be classified as balanced and there is no competition either for certain places nor food.

4. Conclusions
Based on the value of water quality parameter, the water quality in each station was in normal range and it is able to support the growth of diatoms. There were 20 species of diatoms present in the Bengkalis waters and two species, namely Coscinodiscus sp. and Navicula sp. was found in each station. The abundance of planktonic diatoms ranged from 23,041.80 - 286,693.18 ind / l. The average values of biological indices are as follows: diversity index was 1.39-2.32, dominance index was 0.24 to 0.48 ind / l, and the uniformity index was 0.55 to 0.87 ind / l. Based on data obtained, it can be concluded that the ecosystem at Bengkalis Waters can be categorized to relatively balance for biota community and to moderate polluted of water quality.

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