Distribution of Nitrate, Phosphate, Dissolved Oxygen and Macrozoobenthos Density in Belawan River

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Abstract. Belawan River has many community activities such as residential areas, industries, Steam-electric power station, PDAM (local water company) and aquaculture. With this activity the waste is directly discharged into the river water, causing negative impacts on its aquatic environment such as nutrients (Nitrate and Phosphate) and water quality (Dissolved Oxygen) and the state of aquatic biota (Macrozoobenthos). One approach is to use the Purposive Random Sampling method with 5 stations. The approach was in the form of Macrozoobenthos measurement, namely; measurement of density, relative density, and attendance frequency. Measurement of nutrients, namely nitrate, phosphate and measurement of water quality, namely dissolved oxygen. The research results showed that Macrozoobenthos obtained as many as 9 genera. The highest Macrozoobenthos density in the genera of Polymesodaerosa was 629.62 ind/m² at station 4, and the lowest was in the genera of Melanoides sp (Station 1), Macrobrachium sp and Melanoides sp (Station 2), Hirudo (Station 4), and Scylla sp (Station 5) with a density of 3.703 ind/m². Based on nutrient nitrate concentration of 1.18 -7.57 mg/l, it is included as mesotrophic and eutrophic waters, based on phosphate concentrations of 0.14 -0.18 mg/l, it is included as hypertrophic, and dissolved oxygen of 3.8 -5.3 mg/l is included as good water oxygen conditions.

1. Introduction

Belawan River has many activities such as settlements, industries, Steam Power Plants, PDAM (Regional Water Companies) and aquaculture. With this activity the waste is directly discharged into the water body, causing a negative impact on the aquatic environment and the state of the aquatic biota. The water quality conditions of the Belawan River are also influenced by small rivers, the contents carried through these small rivers will differ depending on the condition of the waters and the land that they pass [1].

Nutrient is one of the energy sources used by organisms. The nutrients needed by organisms as an energy source are nitrates and phosphates. Sediment nutrients are in three forms, which are dissolved in sedimentary pore water, absorbed on the sediment surface and contained in the lattice structure of the sediments. Benthos are organisms that live in the bottom of the water. Macrobenthos which has digging properties and deposit eaters tends to be abundant in mud sediments and soft sediments which are areas containing high organic matter such as in sediment pores. Pore water is water found in sedimentary pores. This pore water contains nutrients found in water bodies [2].

The problem is, scientific data on nutrient dynamics with the distribution of Macrozoobenthos in Belawan River is still inadequate, even though the scientific data is one of the important components in the framework of detection and management of rivers in these waters. Therefore, it is necessary to
study the distribution of nitrate, phosphate, dissolved oxygen and macrozoobenthos density in the Belawan river, in which the results obtained can be used to assess the fertility rate of macrozoobenthos in the Belawan river. This research aim was to observe the distribution of nitrate, phosphate, dissolved oxygen and macrozoobenthos density in the Belawan River with various approaches in order to discover the distribution of macrozoobenthos includes; density, relative density and frequency of attendance. The relationship between macrozoobenthos with nitrate, phosphate and dissolved oxygen.

2. Method
The research on sampling was conducted in March to October 2018. With 5 sample locations were picked based on the difference of community activities with 3 repetition, from upstream to estuary site of Belawan river as follows:

| Station | Water Quality       | Tools                          | Measurment Location |
|---------|---------------------|--------------------------------|---------------------|
| 1       | No activity/ Upstream Control | Salam Tani Village, Pancur Batu Sub-district, Deli Serdang District | Laboratory |
| 2       | Habitation, domestic | Sunggal kanan Village, Sunggal Sub-district, Deli Serdang District | Laboratory |
| 3       | Market, Hotel       | Kampung Lalan Village, Sunggal Sub-district, Deli Serdang District | Laboratory |
| 4       | Soy industries, Paper industries | Kelambir Village, Hamparan Perak Sub-district, Deli Serdang District | Laboratory |
| 5       | Downstream (estuary) | Sicanang Village, Medan Belawan Sub-district, Medan Belawan City | Laboratory |

2.1. Sampling of Nitrates, Phosphates and Dissolved Oxygen
Based on the measurement of Nitrates, Phosphates and Dissolved Oxygen can be seen in Table 1 below:

| No | Water Quality     | Tools                          | Measurment Location |
|----|-------------------|--------------------------------|---------------------|
| 1. | Nitrate           | Atomic Absorption Spectrofotometer (AAS)/ Screening | Laboratory |
| 2. | Phosphate         | Atomic Absorption Spectrofotometer (AAS)/ AscorbicAcid | Laboratory |
| 3. | DO (Dissolved Oxygen) | Winkler Method        | In-situ |

2.2. Benthic Sample Collection
Macrozoobenthos samples were taken from five (5) determined location based on the local community activities from upstream to downstream. Purposive random sampling method was used in order to collect the Macrozoobenthos samples. Subsequently, sample collection was conducted using suber net on each sampling point. The collected Macrozoobenthos samples are then put in a plastic bag and preserved using 4% formalin before putting label on the plastic bag. In the laboratory, samples were cleaned from formalin and soaked in clean water for about one day and night, and put in a bottle containing 70 % alcohol afterwards. Identification is then done afterwards using identification book [3,4,5].

2.3. Data Analysis
Data analysis for water quality such as temperature, light penetration and intensity, depth, pH, DO, BOD₅, Macrozoobenthos are done using standard method APHA, (2005)[6].
(1) Density (K)

\[ K = \frac{a}{b} \]  

(1)

K = density  
\( a \) = The number of macrozoobentos(individual)  
\( b \) = Area of plots

(2) Relative Density (KR)

\[ KR = \frac{ni}{\sum N} \times 100\% \]  

(2)

\( ni \) = the number of individuals of a kind  
\( \sum N \) = total of all individuals

(3) Frequency of Attendance (FK)

\[ FK = \frac{\text{The number of plots occupied by a species}}{\text{Total number of plots}} \times 100\% \]

FK = 0-25. (Very Rare), 25-50. (Rare), 50-75. (Common), > 75% (Very Common)

3. Results and Discussions

3.1. Distribution Analysis of Nitrate, Phosphate and Dissolved Oxygen

Based on measurements of Nitrate, Phosphate and Oxygen Dissolved in the Belawan River were as follows:

Table 2. Average score of water quality in the Belawan river

| No. | Chemical Physical Parameters | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 |
|-----|-----------------------------|-----------|-----------|-----------|-----------|-----------|
| 1   | Nitrate (NO\textsubscript{3}) | 1.18      | 0.53      | 4.41      | 7.57      | 3.45      |
| 2   | Phosphate                   | 0.15      | 0.14      | 0.17      | 0.18      | 0.16      |
| 3   | DO                          | 5.3       | 4.4       | 3.8       | 3.8       | 5.2       |

Nitrate concentrations in the Belawan river ranged from 1.18 to 7.57 mg/l, the highest at station IV and the lowest at station II. In the decision of MENLH No. 51 of 2004 [7] attachment III that nitrate 0.008 mg/l means it has passed the threshold of environmental quality standards. Based on nitrate concentration according to Vollenweider (1969) in Effendi (2003) [8], the nitrate content in waters based on their fertility levels is presented in Table 3.

Table 3. Nitrate content in waters based on fertility levels

| Nitrate Content | Category   |
|-----------------|------------|
| 0–1 mg/l        | Oligotrophic|
| 1–5 mg/l        | Mesotrophic |
| 5-50 mg/l       | Eutrophic  |

Nitrate levels in the Belawan river water based on fertility levels (Table 3), are namely mesotrophic and eutrophic, having between 1.18-7.57 mg/liter of nitrate level. The same opinion according to Wetzel (2001) [9], mesotrophic waters have nitrate levels between 1-5 mg/liter, and eutrophic waters have levels ranging from 5-50 mg/liter. The Belawan river is included in mesotrophic and eutrophic waters.
Phosphate levels in the Belawan river range from 0.14 to 0.18 mg / l. The highest was at station IV and the lowest was at station II. In the decision of MENLH No. 51 of 2004 attachment III stated that the standard of the maximum phosphate concentration which feasible for the life of marine biota is \( \text{PO}_4 \) \( P \) of 0.015 mg/L, hence the Belawan river has exceeded the water quality standard. According to Hakanson 2006 \[10\], total phosphate in the sea, namely the range between <0.015 including oligotrophic, 0.015-0.04 including mesotrophic, 0.04-0.13 including eutrophic, > 0.13 including hypertrophic. Then for freshwater the range <0.008 includes oligotrophic, 0.008-0.025 including mesotrophic, 0.025-0.06 including eutrophic, and > 0.06 including hypertrophic. Phosphate concentration in the Belawan river was included as hypertrophic. Phosphate content in waters based on their fertility levels was presented in Table 4 \[11\].

| Phosphate content (mg/l) | Aquatic Fertility |
|-------------------------|------------------|
| 0.000 – 0.020           | Low              |
| 0.021 – 0.050           | Adequate         |
| 0.051 – 0.100           | Good             |
| 0.101 – 0.200           | Very Good        |
| 0.201 or more           | Excellent        |

Phosphate levels in the Belawan river range from 0.14 to 0.18 mg / l was included in very good fertility category (0.101 - 0.200 mg/L). Dissolved oxygen (DO) ranges from 3.8-5.3 mg/L with the highest dissolved oxygen at station I, this was due to the environmental conditions which were sufficiently supportive hence photosynthesis works well to donate a lot of oxygen in these waters. According to Swingle (1969) in Effendi (2003) \[8\], good DO levels for fish survival are > 5 mg/L, presented in Table 5.

| DO Level (mg/L) | Its effect on fish survival |
|----------------|----------------------------|
| <0,3           | Only a few types of fish can survive in a short exposure period |
| 0,3-1,0        | Prolonged exposure can cause fish death |
| 1,0-5,0        | Fish can survive, but their growth is disrupted |
| >5,0           | Almost all aquatic organisms like this condition |

In the decision of MENLH No.51 of 2004 attachment III stated that the standard of maximum concentration of appropriate DO for the life of marine biota is > 5 mg / l. Hence, DO in the Belawan river was still relatively good. DO levels in the Belawan river ranged from 3.8 to 5.3 mg / l, some rivers were still good.

3.2. Density Value (K) (ind / m2), Relative Density (KR) (%) and Frequency of Attendance (FK) (%) Macrozoobenthos in Belawan River.

Results of the Density Value (K) (ind / m2), Relative Density (KR) (%) and Frequency of Attendance (FK) (%) Macrozoobenthos in Belawan River are shown in Table 6 and 7.
Table 6. Density Value (K) (ind/m²), Relative Density (KR) (%) and Frequency of Attendance (FK) (%) Macrozoobenthos at Belawan River at Station I and II.

| No. | Genera            | Stasiun I   | Stasiun II  |
|-----|-------------------|-------------|-------------|
|     |                   | K (ind/m²)  | KR (%)      | FK (%) | K (ind/m²) | KR (%) | FK (%) |
| 1.  | Paguroide sp      | -           | -           | -      | -         | -      | -      |
| 2.  | Scylla sp         | -           | -           | -      | -         | -      | -      |
| 3.  | Macrobrachium sp  | -           | -           | 3.703  | 2.22      | 33.33  |
| 4.  | Hirudo sp         | -           | -           | -      | -         | -      | -      |
| 5.  | Baetis sp         | 25.92       | 25.92       | 66.67  | -         | -      | -      |
| 6.  | Polymesoda erosa  | -           | -           | -      | -         | -      | -      |
| 7.  | Gerris remigis    | 70.37       | 70.37       | 100    | 159.25    | 95.55  | 100    |
| 8.  | Fillopaludina javanica | - | - | - | - | - | - |
| 9.  | Melanoides sp     | 3.703       | 3.70        | 33.33  | 3.703     | 2.22   | 33.33  |

|     | Total             | 99.993      | 100        | 166.656 | 100      |

Table 7. Density Value (K) (ind/m²), Relative Density (KR) (%) and Frequency of Attendance (FK) (%) Macrozoobenthos at Belawan River at Station III, IV and V.

| No. | Genera            | Stasiun III | Stasiun IV | Stasiun V |
|-----|-------------------|-------------|------------|-----------|
|     |                   | K (ind/m²)  | KR (%)     | FK (%)    | K (ind/m²) | KR (%) | FK (%) |
| 1.  | Paguroide sp      | -           | -          | -         | -         | -      | -      |
| 2.  | Scylla sp         | -           | -          | -         | -         | -      | -      |
| 3.  | Macrobrachium sp  | -           | -          | 3.703    | 0.57      | 33.33  |
| 4.  | Hirudo sp         | -           | -          | 3.703    | 0.57      | 33.33  |
| 5.  | Baetis sp         | -           | -          | -        | -         | -      | -      |
| 6.  | Polymesoda erosa  | -           | -          | 629.62   | 98.26     | 100    |
| 7.  | Gerris remigis    | -           | -          | -        | -         | -      | -      |
| 8.  | Fillopaludina javanica | 18.51 | 100 | 66.67 | - | - | - |
| 9.  | Melanoides sp     | -           | -          | 7.407    | 1.15      | 33.33  |

|     | Total             | 18.51       | 100        | 640.73   | 100       | 144.443| 100   |

It can be seen from Table 6 and 7 that Polymesoda erosa at station IV were found to have the highest density value, relative density and attendance frequency with 629.62 ind/m² (K), 98.26 (KR) and 100% (FK), while the lowest were found in genera Scylla sp at Station 5, Hirudo (Station 4) Macrobrachium sp dan Melanoides Sp (Station 2) and Melanoides Sp (Station 1) with density value of 3.703 ind/m².

4. Conclusion
Based on the research results on the distribution of nitrate, phosphate, dissolved oxygen and macrozoobenthos density in the Belawan River, it can be concluded that: Nitrate distribution ranged from 1.18-7.57 mg/l was included as mesotrophic and eutrophic waters, phosphate distribution ranged from 0.14-0.18 mg/l was included as hypertrophic, the distribution of dissolved oxygen (DO) ranged from 3.8 to 5.3 mg/l was included as waters that are still partly good. Macrozoobenthos obtained as many as 9 genera. The highest Macrozoobenthos density in the Polymesoda erosa genera with a density of 629.62 ind/m² at station 4, and the lowest in genera Melanoides Sp (Station 1),
Macrobrachium sp and Melanoides Sp (Station 2), Hirudo (Station 4), and Scylla sp (Station 5) with a density of 3.703 ind/m².

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