Macrozoobenthos diversity as bioindicator of water quality in the Bilah river, Rantauprapat

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Abstract. Bilah river is the largest river and is located right in the densely populated urban areas of Rantauprapat Labuhanbatu, North Sumatra. There are so many community activities that take place such as the baths, water supply company, sand mining, agriculture, transportation and fisheries. The purpose of this study was to determine the diversity of macrozoobenthos as a bioindicator of water quality as well as determining water quality. This study was conducted from November 2016 to October 2017, samples taken from five research stations. From the research results obtained macrozoobenthos which consisting of 4 grade, 7 orders, 11 families and 12 genera. The high density value is a genus of Neanthes sp (18.519 individu/m2) found at station 4. The highest value of diversity index (H') of macrozoobenthos found at station 1 (2.052) and the lowest at station 5 (0.965). Person correlation analysis showed that the DO, BOD5, nitrate, phosphate, COD, substrate, light penetration, the solubility of oxygen, TSS, and TDS was positively correlated with diversity index of macrozoobenthos.

1. Introduction

Bilah River is a water that has been used by some sectors such as sand mining, agriculture, fishery, transportation and also drinking water source for people in Rantauprapat area. The existence of various human activities around the river that caused the river Bilah is allegedly contaminated. Benthos as the basic biota of relatively non-migratory waters is the group of biota that suffers most from water pollution. According [1] the biotic component can provide an overview of the physical, chemical and biological conditions of a water. One biota that can be used as a biological parameter in determining the condition of a waters is Macrozoobenthos.

According to [2] the changing quality of a waters greatly affect the life of biota living in the bottom of the waters among them is Macrozoobenthos. According to [3] Macrozoobenthos is an organism that most or all of its life cycle is at the bottom of the waters, life sessil creep or dig a hole.

Macrozoobenthos is best used as a bioindicator in a waters because of its relatively fixed habitat of life. Changes in water quality and the substrate of his life greatly affect the abundance and diversity of macrozoobenthos. This abundance and diversity is highly dependent on its tolerance and its sensitivity to environmental change. The tolerance range of macrozoobenthos to the environment varies [3]. Environmental components both living (biotic) and dead (abiotic) affect the abundance and diversity of aquatic biota present in a waters, so that the high abundance of individuals of each species can be used to assess the quality of a water. Good quality waters typically have high species diversity and
vice versa in poor or polluted waters [4]. So far, the diversity of Macrozoobenthos and the water quality of the Bilah River has not been known. The purpose of this research is to know the physical, chemical and biological properties of Bilah River waters in relation to water quality standard.

2. Material and Methods
Based on the existing environmental zones 5 different observation stations are assigned. Taking samples of macrozoobenthos was performed as much as 9 replications at each station. Sampling Station 1 is an area where there is no community activity in the upper reaches of the river, geographically located at 2°06'20.78" N 99°49'31" E. The sampling station 2 is a community bathing and agricultural activity, located in the upper river basin, geographically located at 2°06'29.72" N, 99°49'.35" E. Sampling Station 3 is a sand mining site, geographically located at 2°06'22.71" N 99°45'49.82" E. The sampling station 4 is where company water source is taken, geographically located at 2°06'23.17" N, 99°49'26.20" E. The sampling station 5 is a sand mining site and is located downstream of the river, geographically located at 2°06'22.71" N 99°49'34.92" E.

2.1. Sampling methods
The macrozoobenthos samples were taken using a surber mesh and the mesh was placed at the bottom of the river, then the substrate was dredged so that macrozoobenthos netted in the mesh of the surber. The samples obtained were sorted by hand for large samples and floating methods for small samples (which cannot be sorted). The sample was cleaned with water and soaked with 4% formaldehyde for 1 day, then washed and dried, the sample was put into a 70% alcohol-filled sample bottle as a preservative, then labeled. Samples were taken to the laboratory to be identified using reference books.

3. Result and Discussion

3.1. The type of Macrozoobenthos
The macrozoobenthos identified in this study consisted of 3 invertebrate phyla: Annelida consisting of 2 classes, Arthropods consisting of 1 class and Molusca consisting of 1 grade, as shown in Table 1.

| No | Ordo       | Family       | Genus      |
|----|------------|--------------|------------|
| 1  | Haplotaxida| Tubificidae  | Tubifex sp.|
| 2  | Errantia   | Serpulidae   | Neanthes sp.|
| 3  | Diptera    | Chironomidae | Chironomus sp.|
| 4  | Odonata    | Aeshinidae   | Boyeria sp.|
| 5  |            | Gomphidae    | Gomphus sp.|
| 6  |            | Coenagronidae| Argia sp.|
| 7  |            | Libellulidae | Miathyria sp.|
| 8  | Hemiptera  | Naucoridae   | Pelocoris sp.|
| 9  |            |              | Naucoirinae sp.|
| 10 | Ephemeroptera| Leptophlebiidae| Paraleptophlebia sp.|
| 11 | Megastropoda| Pleuroceridae| Pleurocera sp.|
| 12 |            | Pleuroceridae| Goniobasis sp.|

3.2. Index of Diversity (H')
Based on the data analysis, the value of diversity index (H') of macrozoobenthos in each station as that the value of the diversity index (H') obtained from the 5 research stations ranges from H' between 2.052-0.965. The highest index value of diversity (H') is at station 1 that is 2.052. The high index of diversity in station 1 is suspected because the substrate is essentially a soft muddy sand and the presence of rock that supports the life of macrozoobenthos. And the absence of community activity
that took place at the station 1. According to [5] smooth muddy substrate and rocks are the best habitats for macrozoobenthos to obtain food, shelter from the currents and attach themselves while the gravel substrate with sand is easily carried by water currents making it difficult for macrozoobenthos to attach themselves or to settle on the substrate.

3.3. Water quality

Based on research conducted on the five research stations in the rivers waters Rantauprapat obtained the average value of chemical physics factors in Table 2.

| No. | Parameter       | Unit  | St. 1 | St. 2 | St. 3 | St. 4 | Quality Standard* |
|-----|-----------------|-------|-------|-------|-------|-------|-------------------|
| 1   | DO              | mg/L  | 7.75  | 7.35  | 7.35  | 7.125 | >4                |
| 2   | pH              | -     | 6.875 | 6.813 | 6.3   | 7.05  | 6 – 9             |
| 3   | Temperature     | oC    | 22    | 24.5  | 22.75 | 23.5  | Dev. 3            |
| 4   | Light Penetration| m    | 0.6   | 0.835 | 2.675 | 1.3   | -                 |
| 5   | Light Intensity | Candela | 462.5 | 134   | 779   | 285   | -                 |
| 6   | Current velocity| m/s   | 0.694 | 1.833 | 0.685 | 1.2   | -                 |
| 7   | BOD₅           | mg/L  | 1.45  | 1.325 | 1.1   | 1.1   | 3                 |
| 8   | Nitrate (NO₃-N) | mg/L  | 0.40  | 0.33  | 0.43  | 0.39  | 10                |
| 9   | Phosphate Total (PO₄) | mg/L | 0.12  | 0.13  | 0.14  | 0.16  | 0.2               |

*) Based on PP 82 of 2001 on Water Quality Management and Water Pollution Control (for class 2 water Standard Quality).

In Table 2 it can be seen that the temperature of the water at the five research stations ranges from 23 – 24.5°C. The temperature at the five stations is relatively the same, not fluctuating, because the weather conditions during the temperature measurement are relatively the same, so the temperature does not change. In general the temperature range is a normal range for aquatic life creatures including macrozoobenthos. The water temperature values of river waters compared to the criteria of Water Quality Standard I and class II based on Government Regulation Number 82 Year 2011 are still suitable for household, fishery, livestock and agriculture because the water temperature is still within tolerable limits.

The value of dissolved oxygen (DO) obtained from five research stations ranged from 6.9-7.2 mg/l, with the highest values being found in stations 1 and 2 of 7.2 mg/l, this is due to lower station temperature and the organic content is too low. the lowest dissolved oxygen value at station 5 was 6.9 mg/l. the low value of dissolved oxygen at stations 1 and 2 indicates that there are many organic compounds and chemical compounds that enter into the aquatic bodies, so that the presence of organic compounds will lead to aquatic processes conducted by microorganisms that will directly aerobically (requires oxygen). According to [6] the entry of organic materials such as food waste causes the increase of microorganisms in water and consume O₂ dissolved in water for respiration resulting in decreased levels of O₂. Based on Water Quality Standard I and class II according to Government Regulation Number 82 Year 2001 for class I the minimum allowable DO limit is 6 mg/l and for class II the minimum limit is allowed there is 4 mg/l. DO levels at observation stations are greater than DO levels on water quality criteria of class I and class II then these waters deserve to be used as class I and II water.

BOD₅ values in five research stations ranged from 0.6 to 5 mg/l with the highest values found at station 1 of 5 and the lowest at station 5 of 2.9 mg/l, the difference of BOD₅ value in each research station is caused by the amount of different organic material in each station, which is related to the oxygen deficit because the oxygen is used by microorganisms in the process of decomposition of organic matter so that BOD₅ value increases. The high value of BOD₅ at station 1 is suspected because of the large number of community activities in the upper reaches of Bilah River, thus increasing the
organic content in these waters. The low BOD₅ on station 3 is due to the location of this little community activity found at this station.

The mean value of nitrate (NO₃-N) in the Raganuprat river range, ranging from 0.386 to 2.248 mg / l. the highest nitrate value was found at the location of station 1 and lowest at the station location 4. The optimal nitrate content for macrozoobenthic growth was 3.9-15.5 mg / l [7]. The high nitrate element at the location of station 1 is allegedly derived from the number of community activities that produce domestic waste and agricultural waste using fertilizers which resulted in increased levels of nitrate in the body of water. High nitrate-containing water is often found close to the farm. its concentration within the waters will increase as it gets closer from the point of disposal (decreasing as far away from the point of discharge caused by microorganism activity).

The measured phosphate in river blades during the study ranged from 0.258 to 0.614 mg / l. the highest phosphate is found at the location of station 1 while the lowest value is found at station 5. This is due to the entry of wastes entering the water bodies, thus increasing the phosphate value. Phosphorus is mainly derived from sediments which will then infiltrate into ground water and eventually enter into open water systems (aquatic bodies). Moreover it can come from the atmosphere and along with rainfall entering into the water system [1]. Overall, the phosphate content of the measurements in the five observation stations is still below the Standard Water Quality of class I and class II which is allowed to be 0.2 mg / l, thus the waters are suitable for class I and class II.

From the data contained in the Table above can be seen the value of pH measurement results in five observation stations ranged between 7.8-8.1. pH values at five different observational stations are different, but there are also the same depending on the conditions of the waters at each research station. The highest pH values were at stations 4 and 5 of 8.1 and the lowest at stations 1 and 2 of 7.8. The pH values obtained from the five research stations still support the life and development of macrozoobenthos. A normal pH value indicates that the amount of dissolved organic material is small.

The mean value of COD river blades in this study ranged from 49.92 to 72.12 mg / l. The highest COD is obtained at station 1 and the lowest at Station 5. Based on the oxidation ability, the determination of COD value is best considered in describing the existence of organic matter, either biologically or decomposed. Waters containing high levels of COD, requiring oxygen for chemical oxidation processes, this reduces the oxygen reserves in water. Based on Water Quality Standard I and class II according to Government Regulation Number 82 Year 2001 for Class I, the maximum limit of COD allowed is 10 mg/I and grade 125 mg/I. thereby the stations 1,2,3,4 and 5 have exceeded the standard value so it is not feasible to be used as class I water but it is suitable for class III. this is caused by the number of community activities such as baths, agriculture, sand mining and waste Palm Oil Factory located in the upper reaches of the river.

The value of substrate organic content obtained at five observation stations ranged from 2.317-8.153%. the highest substrate organic content was obtained at station 1 of 8.153%, while the lowest at station 2 was 2.317%. Overall, the value of organic content of substrate obtained from the five research stations in this river river is classified and very high.

The basic substrate of a waters is an important factor for the life of macrozoobenthos animals as the animal’s habitat. Each species has a different tolerance range to the substrate and the organic content of the substrate. The existence of different types of substrate base also causes different types of macrozoobenthos obtained in each research station. This is in accordance with the statement [8, 9], that the existence of different substrate causes different fauna or macrozoobenthic community structure.

3.4. Pearson Correlation

Based on the measurement of physico-chemical factor that has been done at each research station, and correlation with Diversity Index, the correlation index is obtained as shown in Table 3.
Table 3. Pearson Correlation Index.

| Parameter | R     |
|-----------|-------|
| Temperature | -0.237 |
| DO        | 0.918(*) |
| BOD_5    | 0.686 |
| NO_3^-   | 0.670 |
| PO_4^{3-} | 0.948(*) |
| pH       | -0.684 |
| COD      | 0.927(*) |
| Substrat | 0.368 |
| P.Cahaya | 0.275 |

Noted: *= Significant of correlation

From Table 3 it can be seen that the result of pearson correlation analysis test between several chemical physics factors of river water is different from correlation level and correlation direction with diversity index. The values of correlation index PO_4^{3-} and COD with the diversity of macrozoobenthos are 0.948 (*) and 0.927 (*) with the degree of correlation significantly. This indicates that PO_4^{3-} and COD have a significant effect on macrozoobenthic diversity index, so increasing PO_4^{3-} and COD levels can lead to lower macrozoobenthic diversity index values.

4. Conclusions

The composition and the total number of macrozoobenthos obtained are all 4 classes: Oligochaeta, Polychaeta, Insecta, and Gastropoda. The highest type of macrozoobenthos composition is Insecta followed by Gastropoda, Oligochaeta and Polychaeta. The types found in Bilah river Rantauprapat amounted to 12 species. The value of the macrozoobenthic diversity index (H’) in the five stations ranged from 0.965 to 2.052, indicating that from all research stations belonging to the mildly polluted groups.

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