Relationship between the surface sediment substrate characteristic with the abundance of macrozoobenthos in River Ranggeh, West of Sumatra

S Aisyah*, J Soedarso, A Satya, M S Syawal
Research Centre for Limnology, Indonesian Institute of Science, Cibinong Science Center, Jl. Raya Bogor Km 46, Cibinong, West Java, Indonesia

*Corresponding author
Email: iis@limnologi.lipi.go.id

Abstract. The bottom substrate is one of the main ecological factors that influence the structure of the aquatic organism. Macrozoobenthos are the organisms living either in the bottom waters or the bottom surface of the waters. The presence of macrozoobenthos in the water is strongly influenced by various environmental factors such as temperature, salinity, dissolved oxygen, pH, and substrate of the bottom water. This study aimed to analyze the characteristics of the physico-chemical of waters and the substrate bottom of River Ranggeh, as well as their relationship to macrozoobenthos abundance. Samples were taken in 2019 for five times (February, March, April, July, and August). Survey method was used in this study. Purposive random sampling was carried out at four stations based on the environmental factors and land use. Insect class was the most dominant class found at all study area with the diversity index value of $H' > 1$ (high diversity). Type of the bottom substrate of River Ranggeh is argillaceous sand with high organic carbon concentration values. The results of the Canonical Correspondence Analysis showed that the abundance of macrozoobenthos was positively correlated with temperature, TSS, P-organic and C-organic, but it was negatively correlated with pH, water flow, DO, Total N, and substrate type.

1. Introduction
River Ranggeh is one of the rivers that enters Lake Maninjau, precisely located in Nagari Sungai Batang, Agam District, West Sumatra. A landslide occurred at the Batang River watershed a year before this study was carried out. The landslide caused partial block of Ranggeh River flow affecting the riverbed substrate and the life behaviour of the organisms which live on it.

The existence of aquatic biota is the most important thing to be considered in the aquatic ecosystems. The bottom substrate is one of the main ecological factors that influence the structure of aquatic organism[1]. Disruption to aquatic biota can affect the environmental balance of these waters [2].

Macrozoobenthos are known to be sensitive to water alteration state, and macroinvertebrates are the most frequently employed as biological marker in monitoring studies [3]. Macroinvertebrates are found in all aquatic habitats. They are less mobile than most other groups of aquatic organism [4].

Macrozoobenthos are living organisms that are crawling, sticking, burying, and burrowing either in the bottom waters or the bottom surface of the waters [5]. Macrozoobenthos plays an important role in
maintaining the balance of aquatic ecosystems but also very sensitive to changes in water quality for supporting their life. The various biotic and abiotic factors strongly influence the presence of macrozoobenthos in the water environment. The abiotic factors involved some aquatic chemical and physical parameters such as temperature, salinity, dissolved oxygen, pH, and substrate of the bottom water [6]. The observation on physical conditions (substrate type) and chemical (the organic material content) in sediments related to the structure of the macrozoobenthos community is very important to be conducted, because sediments are habitat for macrozoobenthos [1].

This study aimed to analyze the characteristics of the physico-chemical of waters and the substrate bottom of River Ranggeh, and their relation to the macrozoobenthos abundance.

2. Materials and Methods

2.1. Sampling and sample analysis

Sampling of macrozoobenthos and water samples were conducted in February–April and July–August 2019. The method of sampling of this study was a survey method. Purposive random sampling was carried out at four stations (figure 1) based on the environmental factors and land use.

![Figure 1. Map of Sampling Sites in River Ranggeh](image)

The measured parameters consisted of macrozoobenthos abundance, water current, physico-chemical of water (temperature, pH, DO, turbidity), total suspended solids, and substrate characteristics (substrate type, total nitrogen, organic phosphorus / P₂O₅, and organic carbon). Sampling of macrozoobenthos at each station was carried out compositively in three locations.

Macrozoobenthos samples were taken using a kick net then put in a plastic bag. The samples were preserved using formalin 10% before being identified at the laboratory. The collected macrozoobenthos was identified. Sediment samples were analysed in the laboratory. Sample analysis methods on the parameters is shown in table 1.
2.2. Data analysis

The quantitative method (an index development) was used for analysing the macrozoobenthos abundance (abundance and Shannon-Winner diversity index). Meanwhile, the analysis of the relationship between physico-chemical parameters of water and sediments to the structure of the macrozoobenthos community was carried out using comparative descriptive methods.

3. Results and Discussion

3.1. Water quality parameters

The results of water quality measurements can be seen in Table 2 which showed the range of water quality parameters among the stations. The range of temperature was 21.56°C - 27.78°C. The highest and lowest temperature was found at SR-1 and SR-5, respectively. Sampling station of SR-1 was located on the upstream while SR-5 on the downstream. The pH value at the upstream sampling station was higher than the downstream sampling station. Range of pH was 7.2 – 8.1. The highest pH was found at SR-1 and the lowest at SR-4.

Table 4 shows that turbidity value at River Ranggeh was quite fluctuated. The range value was 1.8 NTU to 18.9 NTU. The highest value found at SR-2 and the lowest at SR-4. This pattern was like the total suspended solid (TSS) concentration (range of 2.0 mg/L - 12.4 mg/L) which also found to be highest at the station of SR-2. Probably, that pattern caused by the influence of the large amount input of the organic material which came from agricultural activities which found around the station.

Tabel 2. Water Quality of River Ranggeh.

| Sampling site | Temperature (°C) | pH  | Turbidity (NTU) | DO (mg/L) | TSS (mg/L) | Water Current (m/sec) |
|---------------|-----------------|-----|-----------------|-----------|------------|----------------------|
| SR 1          | 21.56           | 8.1 | 3.31            | 8.09      | 5.6        | 2.53                 |
| SR 2          | 23.61           | 8.0 | 18.19           | 7.81      | 12.4       | 2.13                 |
| SR 3          | 24.85           | 7.9 | 3.70            | 6.55      | 2.0        |                      |
| SR 4          | 27.22           | 7.2 | 1.80            | 6.13      | 4.7        | 0.21                 |
| SR 5          | 27.78           | 7.4 | 4.74            | 6.14      | 11.0       | 0.35                 |

Dissolved oxygen concentration in River Ranggeh ranged from 0.21 m/sec to 2.5 m/sec. The highest water current was found at the upper site of the study area (SR-1) and the lowest water current was at SR-4. The station of SR-4 was located on the lower location before downstream. The width of the river flow at this location was narrowed due to a pile of material from landslides. Consequently,
the water flows being slower. The quality of the aquatic environment is very important for the living of organisms [7]. The quality of the aquatic environment governs the presence or abundance of aquatic organism. Anthropogenic activities may also affect the quality of sediments in the environment [8].

3.2 Sediment substrate characteristic
From the analysis of the sediment fraction result, the sand fraction was ranged from 88.72 % to 92.66 % (table 3). The highest percentage was found at SR-1 and the lowest at SR-2. The station of SR-2 showed silt concentration of 3.89 %, this may have corresponded to the higher TSS concentration. The quantity of TSS is a solid which is not dissolved and cause turbidity in water. Silt and clay are forming of the suspended solids [9].

**Table 3.** Percentage of Sediment Fraction of River Ranggeh.

| Sampling site | Silt (%) | Sand (%) | Clay (%) | Substrate type    |
|---------------|----------|----------|----------|-------------------|
| SR-1          | 0        | 92.66    | 7.34     | Loamy sand        |
| SR-2          | 3.89     | 87.72    | 9.33     | Loamy sand        |
| SR-3          | 0        | 92.64    | 7.36     | Loamy sand        |
| SR-4          | 0        | 92.18    | 7.87     | Loamy sand        |
| SR-5          | 0        | 92.19    | 7.81     | Loamy sand        |

Type of the bottom substrate of River Ranggeh was mainly form as loamy sand. The tendency of sand sediment domination in all river segments from upstream to near the estuary in the River Ranggeh may be caused by a large amount of landslide material due to flash floods that occurred just before sampling. River Ranggeh has sandy substrate type because it has a proportion of sand of 85%. This was consistent with the proportion of soil texture classification according to Kohnke (1980), where the substrate will be classified as sand if it has a proportion of sand > 85%, silt <15%, and Clay <10%. Table 4 shows the concentration of total nitrogen, organic phosphorus as P₂O₅, and organic carbon. Total nitrogen concentration in the study area are ranged from 0.03% to 0.05% with the highest value observed on sampling stations of SR-2 and SR-3. The organic phosphorus content in the River Ranggeh sediment substrate was classified into the low to moderate category. Organic phosphorus concentration ranged from 17.37 mg/kg dry weight to 22.44 mg/kg dry weight with the highest value at the SR-5. The phosphorus content in the soil was generally low and varied according to the type of soil, it suggested that phosphorus in the soil is usually relatively difficult to dissolve [10].

**Table 4.** Chemical Characteristic of Sediment of River Ranggeh.

| Sampling site | Total N | Organic P | Organic C |
|---------------|---------|-----------|-----------|
|               | %       | mg/kg dry weight | %        |
| SR-1          | 0.04    | 18.09     | 9.06      |
| SR-2          | 0.05    | 18.61     | 9.33      |
| SR-3          | 0.05    | 17.37     | 8.71      |
| SR-4          | 0.04    | 19.00     | 9.52      |
| SR-5          | 0.03    | 22.44     | 11.24     |

Sediment is common compartment to store phosphorus. Dead plants and animals will be decayed by decomposing bacteria which then being settled down to the bottom of the waters. The phosphorus compounds bound in sediments can undergo decomposition proceeded by the bacteria and through the abiotic process to produce dissolved phosphorus compounds. High phosphorus concentrations can be occurred as resulted from fish excretion, then phosphorus can be settled down to the bottom of the water and accumulated on the sediment compartment [11].
Organic carbon concentration values ranged from 8.71% to 11.24% with the highest value observed on the station of SR-5 and the lowest at SR-3. Organic carbon concentration values at station SR-5 was being included in the high category, although the type of substrate tends to be loamy sand. There was also found a relatively low water current at this sampling station. Therefore, the high value of the organic carbon concentration may be caused by the presence of autochthonous and allochthonous contents mixing with sediment substrate.

3.3 Macrozoobenthos abundance
The insect was the most dominant class found at all study area, while Oligochaeta, Hirudinea, and Gastropod classes were found in SR-4 and SR-5).

**Table 5. Composition of Macrozoobenthos in River Ranggeh (individuals/m2).**

| Class      | Sampling site |
|------------|---------------|
|            | SR-1 | SR-2 | SR-3 | SR-4 | SR-5 |
| Insecta    | 72    | 81   | 5    | 146   | 232  |
| Oligochaeta| -     | -    | -    | 20    | 12   |
| Hirudinea  | -     | -    | -    | 1     | 1    |
| Gastropods | -     | -    | 1    | 1     | 2    |

The species diversity index value in the Ranggeh River ranged from 1.4 to 2.0 (table 6). The value of $H' > 1$ at the study site shows that the diversity of macrozoobenthos in the study location was relatively high. The highest value of $H'$ was found on SR-5. Variations and differences in the value of diversity index are closely related to the type of sediment and the value of water quality at each of station. Generally, the water quality value includes transparency, water current and dissolved oxygen content [1]. In this case, St. 5 showed a low water current value and sufficient dissolved oxygen content.

**Table 6. Abundance and Diversity Index of Macrozoobenthos of River Ranggeh.**

| Sampling site | Abundance (individuals/m2) | Diversity Index |
|---------------|----------------------------|-----------------|
| SR 1          | 72                         | 1.93            |
| SR 2          | 81                         | 1.52            |
| SR 3          | 6                          | 1.48            |
| SR 4          | 168                        | 1.71            |
| SR 5          | 247                        | 2.07            |

The result of CCA showed that the first axis explained that 80.8% of the total variance with the correlation coefficient value between species and habitat showed a high value of 0.999 (figure 2). This indicated that habitat characteristics were strongly correlated to the abundance of macrozoobenthos and probably associated with habitat characteristics.
Figure 2. The Canonical Correspondence Analysis of Macrozoobentos abundance and Physico-chemical Characteristic of River Ranggeh.

4. Conclusion
River Ranggeh showed the characteristics of a basic substrate which tends to loamy sand with a high concentration of organic carbon (9% – 11%), low to moderate concentration of total nitrogen (0.03% – 0.05%) and organic phosphorus (17.37 mg/kg dry weight – 22.44 mg/kg dry weight). The highest abundance of macrozoobenthos (247 individuals/m²) and the diversity index (H') of 2.07 on the river Ranggeh were found at the station of SR-5 with the highest abundance of the insect class.

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