Biological community structure in Krueng Sarah River, Aceh Besar District

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Abstract. This study aims to determine the biological community structure (plankton and macrozoobenthos) in the river from 2017 to 2019. This research method is purposive sampling. The results showed that there were five species of macrozoobenthos, namely Neritrodyas (2017), Polinices hepaticus, Telebra gulata, and Telebralia sulcate (2018), and Tronchus concave (2019). Overall the abundance was high and the same in the three stations. The diversity index ($H'$) is classified as moderate, while the similarity ($E$) and dominance ($D$) are classified as high. Plankton data shows that 15 species of biota were found, namely Rhizosolenia stollerfazhii, Hemialus sp. (2017), Cirtutum hinnalinclla, Budsuehatae sp., Plancoturnix sp., Canccella sp., Cospidothrea sp., Rhizosolenia sp., and Alana bullata (2018) Isothrix spopsi., Fragila sp., Cylindrasperm raciborska, Cuspidothrix sp., Flagiloria sp ., and Cosmarium sp. (2019). Overall, the abundance of plankton is still high. The plankton diversity index is high each year, while the similarity and dominance are low. The water quality data of Krueng Sarah shows that it is still within the tolerance limits for macrozoobenthos and plankton. Therefore, the overall structure of the biological community in Krueng Sarah is still classified as suitable for natural balance.

1. Introduction
Sarah river is one of the rivers located in Leupung sub-district, Aceh Besar district. In general, rivers have multiple functions, such as providing clean water, generating electricity, sports facilities, and recreation/tourism. Besides, the rivers are also a place for aquatic biotas, such as fish, shrimp, crab, and benthos, to live. Sarah river has water circulation that continues to flow to the Lhoknga beach, which becomes surface run-off.

Benthos and plankton are organisms that live in diverse waters. Benthos is organisms that inhabit the bottom waters and live in or are attached to the bottom waters' sediments. Based on their body size, benthos is divided into three groups: macrobenthos, namely the benthos group with a size of > 2 mm; meiobenthos, namely the benthos group measuring 0.2–2 mm, and microbenthos, namely the benthos group measuring <0.2 mm [1]. While plankton is organisms that float in the waters that cannot fight the current [2]. Plankton is also an organism that plays a crucial role as primary productivity in waters [3].
Apart from nekton, to assess the waters' condition can also use the community structure of invertebrates such as macrozoobenthos and plankton. Therefore, to find out the condition of Sarah river waters, which until now is densely packed with tourists and anthropogenic, the authors feel the need to study these waters' conditions using the macrozoobenthos and plankton community structure approach. Thus, this study aims to determine macrozoobenthos and plankton's community structure over the last three years (2017, 2018, and 2019) through indices of diversity, evenness, dominance, abundance, and density. Several related studies have been carried out in Aceh waters: the structure of the macrozoobenthos community in the Lamnyong river, Aceh Province [4], and the structure of the macrozoobenthos community in Danau Gosong Village, Aceh Singkil Regency [5].

2. Materials and Methods

2.1. Time and Place
This research was conducted in the Sarah river, Aceh Province in March 2017, April 2018, and March 2019.

2.2. Method
Sampling for benthos was carried out using a random sampling method. Paralon pipe with a diameter of 10 cm plugged into the bottom of the water, and then the benthic samples were filtered. The sample was identified morphologically, which refers to the benthos identification book [6]. Then, water sampling is carried out to measure the aquatic environment parameters, including temperature, depth, pH, and current velocity, which are calculated in-situ.

2.3. Data Analysis

2.3.1. Benthos
The macrozoobenthos density index refers to [7] using the following formula:

\[ D = \frac{\sum N_i}{A} \]

Where, D is the density index for macrozoobenthos (ind/ m²); Ni is the number of individuals i, and A is the area (m²).

The macrozoobenthos diversity index was calculated using the Shannon-Weiner formula [8]:

\[ H'(D) = -\sum_{i=1}^{n} p_i \ln p_i \]

Where, \( p_i \) is the abundance of each species.
\[ H' = -\sum \pi_i \log_2 \pi_i \]

Where, \( H' \) is the Shannon-Weiner diversity index; \( \pi_i \) is the number of individuals of species \( i \) / the total number of all individuals of species \( i \); \( N \) is the total number of all individuals; \( \log_2 \pi_i \) is 3.321 x \( \log \pi_i \). The diversity index category refers to [9]; \( H' < 1 \) belongs to the low category and unstable community; \( 1 < H' \leq 3 \) belongs to the category of medium and community with moderate stability; \( H' > 3 \) belongs to the high category and a stable community.

The macrozoobenthos similarity index was calculated using the Krebs formula [9]:

\[ E = \frac{H'}{H_{\text{max}}} \]

Where, \( E \) is the similarity index; \( H' \) is the diversity index; \( H_{\text{max}} \) is 3.321928 \( \log S \), and \( S \) is the number of species found. The similarity index value ranges from 0 - 1. If the similarity index is close to the value 0, then the individual distribution of each species is not the same. In the ecosystem, there is a tendency to dominate species due to environmental and population factors instability. If the similarity index approaches a value of 1, then the ecosystem is in a relatively stable condition, the number of individuals per species is relatively the same.

The macrozoobenthos dominance index was calculated using the Odum formula [8]:

\[ C = \sum \frac{n_i^2}{N} \]

Where, \( C \) is the Dominance Index; \( n_i \) is the number of individuals of species \( i \), and \( N \) is the total number of individuals. Dominance index values can be classified as follows [9], where \( 0 < C \leq 0.5 \) is low dominance; \( 0.5 < C \leq 0.75 \) is moderate dominance; and \( 0.75 < C \leq 1.00 \) is high dominance.

2.4. Plankton

Plankton identification was carried out using a microscope at 10x magnification using the census method. Identification of plankton species is carried out by observing the characteristics of shape, genus, class, then classified to the genus stage and identified using the plankton identification books [10, 11, 12, 13]. The plankton abundance index is calculated using the formula [14]:

\[ N = \frac{O_i}{O_p} \times \frac{V_r}{V_o} \times \frac{1}{V_s} \times \frac{n}{p} \]

Where, \( N \) is the number of individuals per liter (ind/ l); \( O_i \) is the dark area of the cover of the preparation (400 m\(^2\)); \( O_p \) is the area of one field of view (12.7 m\(^2\)); \( V_r \) is the volume of filtered water (30 ml); \( V_o \) is the volume of 1 sample water drop; \( V_s \) is the volume of water filtered by planktonet (100 L); \( N \) is the amount of plankton in the entire visual field, and \( p \) is the number of observed fields of view.

The plankton diversity index is calculated using the Shannon-weiner equation [15]:

\[ H' = \sum \pi_i \ln \pi_i \]

Where, \( H' \) is the plankton diversity index; \( \pi_i \) is the ratio of the number of individuals \( i \)-to the total number of individuals (\( n_i / N \); this is the number of individual species, and \( N \) is the total number of individuals. According to [8], the range of species diversity index is high if the value of \( H' > 3 \), medium diversity if the value of \( H' \) is 1-3, and species diversity is low if the value of \( H' < 1 \).

The plankton similarity index is calculated using the Brower and Zar equation [16] with the formula:

\[ E = \frac{H'}{H_{\text{max}}} \]
Where, $E$ is the similarity index; $H'$ is the diversity index, and $H_{\text{max}} = \log 2S = 3.3219 \log S$; $S$ is the number of taxa or species. The species similarity index ranges from 0-1. Furthermore, the similarity index based on [15] is categorized as follows: $0 < E \leq 0.5$ is classified as a depressed community; $0.5 < E \leq 0.75$ is classified as an unstable community; and $0.75 < E \leq 1$ classified as a stable community.

The plankton dominance index is calculated using the Simpson equation [17]:

$$C = -\sum_{i=1}^{S} \left( \frac{n_i}{N} \right)^2$$

Where, $C$ is the plankton dominance index; $n_i$ is the number of individuals of species $i$; $N$ is the total number of individuals. The plankton dominance index criterion: if $0 < C \leq 0.5$, then no genus dominates and if $0.5 < C < 1$, then there is a dominant genus [17].

3. Results and Discussion

3.1. Macrozoobenthos Density ($D$)

Based on the research results in Sarah waters in 2017, Neritrodyas is a macrozoobenthos only 1 species was found. In 2018 there were three macrozoobenthos species, namely Polinices hepaticus, Telebra gulata, and Telebralia sulcata. In 2019, 1 macrozoobenthos species was obtained, namely Tronchus concavus. The highest macrozoobenthos density in the three observation years is in 2018 at station 2. It is thought that in that year the environmental conditions of sarah river are very supportive of macrozoobenthos life. This is also in accordance with the statement Octavina et al. [4] who conducted research in the same year also found the highest macrozoobenthos density at station 2 in 2018 (Figure 2).

![Figure 2](image)

**Figure 2.** The density of macrozoobenthos in Sarah waters in the last three years

| Station | Year | Diversity Index ($H'$) | Similarity Index ($E$) | Dominance Index ($C$) |
|---|---|---|---|---|
| 1 | 2017 | 0 | 0 | 1 |
| 2 | 2018 | 0.6 | 4 | 1 |
| 3 | 2019 | 0 | 1 | 1 |

Note: $H'$ is diversity; $E$ is similarity; and $C$ is dominance

The highest benthic diversity index ($H'$) was found in 2017 at station 2, while the lowest was obtained in 2018 and 2019. The diversity of benthos during the last three years is classified into...
moderate diversity where $1 < H' < 3$ is medium diversity [18]. The similarity index ($E$) belongs to the high category with a value of 0.6, where $E > 0.6$ is high species similarity [19]. The dominance index is high, with a value of 4 because there are no families that dominate Sarah river.

The density of macrozoobenthos in Sarah's river over the past three years has been relatively the same, only in 2017 at station 2 doubled. The high density is thought to be because macrozoobenthos have the ability to adapt to their habitat and are able to breed well. It is also because Sarah's river are overgrown with trees so it becomes one of the sources of food and as a breeding ground. This is in accordance with research [4, 5, 22, 23, 24, 25, 26, 27, 28] stating that the highest density obtained is due to the ability of macrozoobenthos that occupy various habitats so that more opportunities to breed. Where at the location inhabited plants can be functioned as a place to lay eggs and where macrozoobenthos look for food sources.

The diversity of macrozoobenthos in Sarah's waters is relatively moderate. It is thought that a community that has a diversity of types is very easy to continue with small environmental changes. In the event of increased pollution, there will be a very significant change in community structure that causes the diversity index to be low ($H' < 1$). Conversely, if the compounds that cause pollution get into fewer waters and food sources are sufficient, then the Type Diversity Index can be higher than before. The high diversity of macrozoobenthos is thought to be influenced by sandy aquatic substrates making it less good for macrozoobenthos' survival and causing low diversity.

Furthermore, the similarity index ($E$) found during the study ranged from 0-1. The greater the value of the similarity index, indicating that the number of species with other species spreads evenly. Conversely, if the smaller the value of the species similarity index indicates that the number of species with other species spreads unevenly, it is in accordance with the statement [8], that the greater the value of similarity indicates the similarity of the species in high waters.

The quality of Sarah's waters in the last three years is suitable for the survival of macrozoobenthos, as it is still at tolerance for the life of the organism. The range of physical and chemical parameters found in Sarah's waters from 2017, 2018, and 2019 is that the pH ranges from 7-8.5, temperatures range from 22°C - 36.3°C, depths range from 0.07 m – 0.7 m, and salinity 0 due to fresh water.

Based on the results of plankton research conducted in 2017, 2 plankton genera were found at the research location, namely *Rhizoselenia stolterfazhii*, *Hemialus* sp.. In 2018, 7 plankton genera were found, namely *Civutum hinnalinclla*, *Bulduehatae* sp., *Plancotturnix* sp., *Canccella* sp., *Cospiodothrea* sp., *Rhizosolenia* sp., and *Alana bullata*. In 2019, 6 plankton genera were found, namely *isothrix* sp., *Fragila* sp., *Cylindruspermopsi raciborska*, *Cuspiodorhix* sp., *Flagiloria* sp., and *Cosmarium* sp.

The results of measurements of plankton abundance show varying results. The highest plankton abundance in Sarah waters in 2019 was at station 1, while the lowest was found at station 3 in 2018 (Figure 3).
The plankton diversity index ($H'$) ranges from 0.64 to 1.15. The highest diversity index value ($H'$) was found in 2019 at station 3 of 1.15. The lowest diversity index was found in 2017 and 2018 at station 2, with a value of 0.64. The highest similarity index (E) was found in 2017 at station 2, with a value of 0.92. Conversely, the lowest was found in 2018 of 0.33. The similarity between species is evenly distributed [19]. The highest dominance index (C) was found in 2017 at station 3 with a value of 1.00, and the lowest was found in 2018 at station 2 of 0.33.

The highest abundance of plankton in Sarah's waters in the last three years is in 2019 at station 1. The high abundance of plankton is due to its high nutrient content. It is thought station 1 is close to the mainland thus adding nutrient supplies to the waters. The difference in the value of the diversity index and the varying similarity of the waters is due to physical factors.

The dominance of plankton close to the value of 1 indicates that there is a genus that dominates the waters. This is in accordance with the assertion [5] that the higher the dominance of a species then indicates the absence of a particular species, instead the smaller the value of the dominant index then indicates that no species dominates the waters.

4. Conclusion
Based on the research results over the last three years (2017-2019), there were five species of macrozoobenthos, namely *Neritodyas* (2017), *Polinices hepaticus*, *Telebra gulata*, and *Telebralia sulcate* (2018), and *Tronchus concave* (2019). Plankton data shows that 15 species of biota were found, namely *Rhizoselenia stolterfazhii*, *Hemialus* sp. (2017), *Civutum hinnalinclla*, *Bulduehatae* sp., *Planctotturnix* sp., *Canccella* sp., *Cospidothrea* sp., *Rhizosolenia* sp., and *Alana bullata* (2018) *Isothrix spopsi*, *Fragila* sp., *Fragilu* sp., *Cylindrusperm raciborska*, *Cuspidothrix* sp., *Flagiloria* sp. and *Cosmarium* sp. (2019). The water quality data of Krueng Sarah shows that it is still within the tolerance limits for macrozoobenthos and plankton. Therefore, the overall structure of the biological community in Krueng Sarah is still classified as suitable for natural balance.

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