The distribution of the macro-zoobenthos community based on the characteristics of the mangrove sediments in Aceh Besar

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Abstract. Spatially, the composition of mangrove vegetation and macro-zoobenthos varies due to the characteristics of the sediments substrate in the mangrove area. Therefore, the purpose of this study is to analyse the elements contained in the sediments in the mangrove area and to identify macro-zoobenthos species based on the characteristics of the sediment substrate in Peukan Bada and Baitussalam of Aceh Besar district. The method used in this research is the coring method for sediment sampling, while the sediment characteristics analysis was carried out by the sieve method. For the presence of mangroves, the transect method is applied and analysed based on the identification of mangrove species characteristics in the laboratory. Meanwhile, macro-zoobenthos were collected based on mangrove density using hand grabs and sieved at a size of 0.5 mm, then analysis of the dominance and partial correlation between the sediments of the mangrove area and the presence of macro-zoobenthos was carried out. The results show that 89% of the substrate is a muddy fine sand sediment with the dominance of the mangrove species Rhizopora mucronate and Sonneratia alba species. The dominance level of macro-zoobenthos is in the low to high category with a dominance value of 0.47 - 0.88. Furthermore, the partial correlation test for mangroves, macro-zoobenthos and sediment showed that there was a strong relationship between them.

1. Introduction

Geographically, Aceh Besar District is located at positions of 5.2° - 5.8° North Latitude and 95.0° - 95.8° East Longitude [1]. Aceh Besar District has an area of 2903.50 km², with 10% of the village is a coastal area [1] and 45% of the coastal area of Aceh Besar is a mangrove ecosystem. Besides mangroves, the coastal area of Aceh Besar is also rich in seagrass and coral reefs [2]. However, many of these ecosystem areas have been damaged, especially mangrove areas especially after the 2004 tsunami.

Damage to mangrove areas in Aceh Besar has been occurring since 1960 due to the conversion of land into ponds [2]. This occurred during the expansion of the shrimp business in Indonesia and in the 1980s was the culmination of a massive conversion of mangrove land for shrimp farming [4]. This
damage made Aceh Besar District vulnerable to disasters and this was clearly visible when the tsunami occurred. The estimated mangrove damage caused by the tsunami in Aceh Besar was 100% (approx. 26,823 ha) [5].

Mangrove forest vegetation in coastal areas physically plays an important role as a retainer for sediment and toxic wastes carried by waterways [6]. Sediment in mangrove areas biologically serves as a place to live and a place to find food for living organisms in the area [7]. The nutrients from mangrove sediments are generally formed by the organic material contained in them [8]. The sediment in the mangrove area has a high nutrient content due to the mixing of sediment from the sea which contains a lot of minerals with the fallen mangrove leaf litter [9, 10]. According to [2] stated that nitrates and nitrites play an important role for organisms in mangrove forest areas. These nutrients serve as the main nutrient to determine the stability of mangrove growth, where the nutrients in the mangrove sediments will be distributed by environmental factors such as the dynamics of currents, waves and tides [11], biological factors such as mangroves and living ecosystems and human or anthropogenic [3, 4].

One of the efforts to enrich knowledge about mangrove ecosystems is to study mangrove substrates in relation to the presence of macro zoobenthos. This is an important basis for studying the structure and dynamics of complex mangrove ecosystems. Substrate is an essential living medium for various organisms where there is a relationship between decomposition, grazing and foraging in a food chain. The mangrove root system provides a denser substrate than the surrounding mud substrate which functions as a growth medium for photosynthetic algae. Mangrove detritus is known to have an important role as a food source in decomposing food chains such as macro-invertebrates. Invertebrate community life in the mangrove ecosystem consists of mollusks, Arthropods, Sipuncula, Nematoda, Nemertean, Platyhelminthes, and Annelida. Molluscs and crustaceans dominate benthic fauna communities in most mangrove ecosystems.

The potential of the Aceh Besar coast can be designed to conserve tropical mangrove forest ecosystems. Mongroves on this coast have a potential area of more than 26,000 ha. However, the ecological condition of mangroves has not been studied seriously. Several studies in this area have been conducted by [11], which examines the diversity of gastropods and bivalves based on mangrove characteristics in intertidal areas. However, this study did not discuss the sediment problem which is closely related to the presence of mangroves. Sediment characteristics provide a variety of information which is closely related to the presence of benthos. [12] examined the relationship between sediment characteristics and macro zoobenthos abundance in the Krueng Aceh estuary. The results of this study indicate that the abundance of benthic species is closely related to the different types of substrate that exist. On the other hand, [14] states that the density of mangrove species is very much affected by the types of sediments that exist. Therefore, this condition makes research on the relationship between substrate and mangrove density on the presence of macro zoobenthos interesting. One of the objectives of this study is to observe the relationship between macro zoobenthos that live in the mangrove substrate on the coast of Aceh Besar.

2. Method

This research was conducted in the coastal area of Peukan Bada District and Baitussalam District, Aceh Besar District. Analysis of sediment elements was carried out at the Soil Laboratory of the Faculty of Agriculture, Syiah Kuala University and identification of macro zoobenthos was carried out at the Laboratory of the Faculty of Marine Affairs and Fisheries, Syiah Kuala University. This research was conducted from May to June 2019 and the research location can be seen in Figure 1.

2.1. The determination of Location and Research Station

The research area is divided into 2 locations, namely the coastal area of Peukan Bada District as location 1 and the coastal area of Baitussalam District as location 2. Each location is divided into 3 stations so that there are 6 stations. At each station 3 repetitions were carried out. These two different locations are used as a comparison of the rehabilitation locations, while the repetition is done to obtain accurate data at each station. Each station is distinguished by the presence or absence of mangroves, the difference in
this category is to see the differences in sediment content and the suitability of mangroves planted at the research location. The coordinates of the research stations are presented in Table 1.

Determination of the station is done by using purposive random sampling method, namely by dividing the sampling location into several layers or strata based on certain characteristics and random sampling. These stations are expected to represent sediment elements and mangrove species that exist in the research location.

![Figure 1. The location of study area.](image)

| Sub-district     | Location of data taken | Coordinate                  |
|------------------|------------------------|-----------------------------|
|                  |                        | Latitude | Longitude        |
| Peukan Bada      | 1                      | 5°32'56,45\(^\circ\) N | 95°14'20,46\(^\circ\) E |
|                  | 2                      | 5°32'45,00\(^\circ\) N | 95°14'41,00\(^\circ\) E |
|                  | 3                      | 5°32'43,88\(^\circ\) N | 95°15'03,56\(^\circ\) E |
| Baitussalam      | 4                      | 5°36'30,00\(^\circ\) N | 95°23'35,90\(^\circ\) E |
|                  | 5                      | 5°36'59,10\(^\circ\) N | 95°23'33,16\(^\circ\) E |
|                  | 6                      | 5°37'10,42\(^\circ\) N | 95°23'45,97\(^\circ\) E |

2.2. Sediment Sampling

Sediment sampling was done by coring method with a depth of 25 - 50 cm of the sample sediment. The coring method is a technique used to carry sediment from the base to the surface for analysis. Sediment collection using a tube core or a Parallon pipe with a diameter of 2.5 inches. Sediment sampling by plugging a pipe which is then lifted up. The sample is then put into a plastic bag. The samples that have been collected are then taken to the laboratory for analysis of the elemental content and types of sediment. The sediment sieve analysis method will also be carried out to determine the texture of the sediment in each sample taken.

The sediment sample was dried for six days, then 500 g was taken for analysis using the dry sieve method on a 2 mm sieve analysis; 1 mm; 0.5 mm; 0.250 mm; 0.125 mm; 0.063 mm; and the sample is collected with the container medium. After sieving, the remaining sediment samples in each filter are then dried again and then weighed using digital scales.
Table 2. Sediment parameters observed.

| No | Parameter     | Unit | Method/tool       |
|----|---------------|------|-------------------|
| 1  | Subtract type | %    | Sieve             |
| 2  | C-Organic     | %    | Walkey and Black  |
| 3  | Soil pH       |      | pH meter for soil |
| 4  | Phosphor      | Mg/kg| Bray Curtis       |
| 5  | N-total       | %    | Kjeldhal          |
| 6  | Organic matter|      | Walkey and Black  |

During the sediment sampling, the mangrove species were also identified at the location of the collection. In areas where mangroves were not overgrown, some sediment samples were also taken to analyse sediment elements so that the suitability of the growing mangrove species was known. It is important to determine the types and characteristics of the sediment as a substrate for mangrove growth to determine the zoning pattern for mangrove growth to be analysed. Sediment parameters are observed in Table 2.

2.3. Macrzoobenthos Sampling

Retrieval of macro zoobenthos data using a transect squared 1 m x 1 m macro zoobenthos was taken retroactively. Sampling was done by digging the substrate by using a shovel as deep as 20-30 cm, and samples on the surface of the substrate were taken by hand.

The macro zoobenthos sample was then sieved using a 0.5mm sieve to separate the soil contained in the sample. The sample is then put into a sample bottle that has been labelled and added with 70% alcohol, preservation for further identification in the laboratory of the Faculty of Marine Affairs and Fisheries of Syiah Kuala University.

2.4. Sediment Data Analysis

The calculation of the percentage by weight of sediment is calculated to determine the sediment fraction using the formula [12]:

\[
\text{percentage of weight of sediment fraction } i = \frac{\text{sediment weight to } - i}{\text{weight of total sediment}} \times 100%
\]

Meanwhile, the average grain size of the sediment can be determined by the formulation:

\[
d = \sum \frac{\% \text{ weight sediment fraction } \times \text{sediment size}}{100}
\]

2.5. Benthos Dominance Analysis

Dominant mangroves were analyzed using the dominance index with the formulation [15]:

\[
C = \frac{1}{N^2} \sum_{i=1}^{s} n_i^2
\]

Information:
C = Simpson dominance index
Ni = Number of individuals of type i
N = total number of individuals of all species

The dominance index has a range of values:
0 < C ≤ 0.5 = Low dominance
0.5 < C ≤ 0.75 = moderate dominance and fairly stable environmental conditions
0.75 < C ≤ 1.0 = High dominance

2.6. Partial Correlation

Partial correlation is a statistical method to determine the pure relationship between an independent variable (X1) and the dependent variable (Y) by observing or controlling the other independent variables
**3. Result and Discussion**

**3.1. Sediment Texture Analysis**

The results of sediment analysis in mangrove rehabilitation areas in Peukan Bada and Baitussalam districts can be seen in Table 4 below.

| Station  | Sediment weight (%) | Mean size (mm) |
|----------|---------------------|----------------|
|          | 2.0-4.0 mm          |                |
|          | VC sand             |                |
| Loc. 1   | 11.4                | 0.7            |
| Loc. 2   | 5.3                 | 0.7            |
| Loc. 3   | 0.7                 | 0.7            |
| Loc. 4   | 0.8                 | 0.7            |
| Loc. 5   | 2.0                 | 0.7            |
| Loc. 6   | 0.7                 | 0.7            |
|          | 1.0-2.0 mm          |                |
|          | C sand              |                |
| Loc. 1   | 6.2                 | 0.7            |
| Loc. 2   | 10.6                | 0.7            |
| Loc. 3   | 3.5                 | 0.7            |
| Loc. 4   | 1.7                 | 0.7            |
| Loc. 5   | 2.1                 | 0.7            |
| Loc. 6   | 2.4                 | 0.7            |
|          | 0.5-1.0 mm          |                |
|          | F sand              |                |
| Loc. 1   | 13.2                | 0.7            |
| Loc. 2   | 18.8                | 0.7            |
| Loc. 3   | 9.4                 | 0.7            |
| Loc. 4   | 4.6                 | 0.7            |
| Loc. 5   | 5.5                 | 0.7            |
| Loc. 6   | 16.3                | 0.7            |
|          | 0.25-0.5 mm         |                |
|          | VF sand             |                |
| Loc. 1   | 62.8                | 0.7            |
| Loc. 2   | 43.0                | 0.7            |
| Loc. 3   | 46.5                | 0.7            |
| Loc. 4   | 89.0                | 0.7            |
| Loc. 5   | 86.7                | 0.7            |
| Loc. 6   | 77.9                | 0.7            |
|          | 0.125-0.25 mm       |                |
|          | VF sand             |                |
| Loc. 1   | 4.0                 | 0.7            |
| Loc. 2   | 20.5                | 0.7            |
| Loc. 3   | 37.9                | 0.7            |
| Loc. 4   | 18.0                | 0.7            |
| Loc. 5   | 2.7                 | 0.7            |
| Loc. 6   | 1.6                 | 0.7            |
|          | 0.063-0.125 mm      |                |
|          | mud                 |                |
| Loc. 1   | 1.7                 | 0.7            |
| Loc. 2   | 1.1                 | 0.7            |
| Loc. 3   | 1.5                 | 0.7            |
| Loc. 4   | 1.2                 | 0.7            |
| Loc. 5   | 0.9                 | 0.7            |
| Loc. 6   | 0.7                 | 0.7            |
|          | 0.038-0.063 mm      |                |
|          | silt                |                |
| Loc. 1   | 0.7                 | 0.7            |
| Loc. 2   | 0.7                 | 0.7            |
| Loc. 3   | 0.5                 | 0.7            |
| Loc. 4   | 0.8                 | 0.7            |
| Loc. 5   | 0.2                 | 0.7            |
| Loc. 6   | 0.4                 | 0.7            |

VC = very coarse; C = coarse; F = fine; VF = very fine

The results of the sediment fraction in the two research locations were dominated by medium sand (0.25-0.5 mm) with the highest percentage at location 4 at 89.0% and the lowest at location 2 at 43.0%. The research location is a location that is directly related to the sea so that the hydro-oceanographic dynamics and the presence of mangroves in this area greatly affect the size of the sediment which is generally medium sandy [17]. The high sand being in this location according to [18] is due to the very dominant sea influence. Meanwhile, the results of the sediment grain size analysis also determine the type of sediment in the study location [19].

In general, sandy sediments are terrigenous, whose composition is influenced by the original location where it comes from [20]. [21] said that in the sediment deposition process, oceanographic conditions have a role in selecting the size of the sediment type, causing variations in the size of the species. Sediments that have coarser fractions are usually not easily carried away by currents, but sediments with finer fractions will be carried away and settle in calmer water areas.

**3.2. Mangrove and macrozoobenthos dominance index**

Dominance index (C) is calculated to determine the extent to which one biota group dominates another group. Large dominance will indicate an unstable and depressed community [22]. The range of dominance index values was divided into three ranges, namely 0 <C ≤ 0.5 with the low dominance category, 0.5 <C ≤ 0.75 medium category and the last 0.75 <C ≤ 1.0 with the high dominance category. Based on the analysis of the dominance index (C), the index results for mangroves and macrozoobenthos were low and high. Mangrove and macrozoobenthos dominance index can be seen in Table 6.

The mangrove dominance index in Peukan Bada and Baitussalam Districts shows a range of values of 0.21 - 0.34 with a low category, which means that no mangrove species dominate at each station. The environmental conditions are stable and there is no ecological pressure on the mangroves in that location.
The low dominance of mangroves at each station is because the mangroves in this area are rehabilitated mangroves so that many mangroves are uniform and there is no dominance.

The macro zoobenthos dominance index in two area in Aceh Besar District shows a value of 0.47 - 0.88 with the low to high category. The lowest dominance index is at Station Location 1 with a value of 0.47 and the highest is at location 6 with a value of 0.88.

Table 4. Dominance Index of Mangroves and Macro zoobenthos

| Station     | Mangrove | Category | Macro zoobenthos | Category |
|-------------|----------|----------|------------------|----------|
| Location 1  | 0.33     | Low      | 0.59             | Medium   |
| Location 2  | 0.34     | Low      | 0.79             | High     |
| Location 3  | 0.34     | Low      | 0.47             | Low      |
| Location 4  | 0.33     | Low      | 0.76             | High     |
| Location 5  | 0.21     | Low      | 0.74             | Medium   |
| Location 6  | 0.34     | Low      | 0.88             | High     |

3.3. Characteristics relationship of sediments, mangroves and macro zoobenthos

Based on the mangrove, macro zoobenthos and sediment data that have been obtained then a partial correlation test is carried out. Partial correlation (partial correlation) is an extension of simple correlation or Pearson correlation. This correlation can not only be used on one control variable but can be used for more than one control variable [16]. The table of partial correlation test results from mangrove, macro zoobenthos and sediment data can be seen in Table 7.

Table 5. Partial Correlation Test

| Aspect | 2.0-4.0 gravel | 1.0-2.0 VC sand | 0.5-1.0 C sand | 0.25-0.5 F sand | 0.125-0.25 VF sand | 0.063-0.125 mud | 0.038-0.063 silt |
|--------|----------------|-----------------|----------------|-----------------|-------------------|----------------|-----------------|
| R      | 0.898          | 0.976           | 0.824          | 0.876           | 0.761             | 0.792          | 0.639           |
| Sig    | 0.038          | 0.004           | 0.086          | 0.057           | 0.135             | 0.111          | 0.246           |

From Table 7 it can be seen that there is a very strong relationship between mangroves, macro zoobenthos and sediments found in Peukan Bada and Baitussalam Districts. The relationship between the three variables is positive with correlation values ranging from 0.639 to 0.976. According to [23] the correlation coefficient value interval 0.60 - 0.799 indicates a strong level of relationship, the interval value 0.80 - 1.0 indicates a very strong level of relationship. The highest correlation value was found in the coarse sand fraction (1-2 mm) with a value of 0.898 and the lowest correlation value for the silt fraction (0.038-0.063 mm) with a correlation value of 0.639.

The significant test values on the correlation of mangroves, macro zoobenthos and sediments in table 4.5 vary widely. There are several sediment fractions that show a significant value <0.05, such as the gravel fraction with a value of 0.038, very coarse sand with a significant value of 0.004 and medium sand with a correlation value of 0.057. The significant value <0.05 indicates that these three fractions have a significant effect. Unlike the case with the coarse sand, fine sand, very fine sand and silt which has a significant value> 0.05, which indicates that this fraction has no significant effect.

4. Conclusions

Based on the analysis of the results of research on sediment elements, mangrove species and the presence of macrozoobenthos in the mangrove rehabilitation area in Peukan Bada and Baitussalam Districts, it can be concluded that the sediments in the mangrove areas of Peukan Bada and Baitussalam Districts have medium sand grains with a percentage of 43.0% - 89.0 % with an average grain size of 0.26 - 0.52 mm. The level of macrozoobenthos dominance in the two mangrove areas studied was in the low to high
category with a dominance value of 0.47 - 0.88. The results of the partial correlation test for mangroves, macrozoobenthos and sediments show that there is a strong to very strong relationship with a value of 0.639 - 0.976 with fractions that have significant values, namely the fraction of gravel, very coarse sand and medium sand.

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