Characteristics of sediment in the intertidal zone of the west coast waters of Aceh Besar

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Abstract. Aceh Besar west coast is one of the beaches on the west coast of Aceh Besar Regency located in Aceh Province, the tip of Sumatra Island, Indonesia. In the intertidal zone of the west coast there are many human activities such as tourism, industry, and fisheries. The purpose of this study is to determine the characteristics of sediments including the physical and chemical of sediments in the intertidal zone of the west coast of Aceh Besar. The method used in this study is a survey method, which is carried out in the field directly to collect the data and samples. Samples were analyzed in the laboratory to determine the texture of sediment and its percentage. Sediment texture found in the intertidal zone of the west coast of Aceh Besar are sand and sandy loam. The sediment fraction is dominated by the sand fraction with a percentage of 81-90%. The content of organic carbon in the sediment is in the low category. The salinity value of the sediment shows high salinity results and the pH value of the sediment in the intertidal zone shows an alkaline pH category at each research station.

1 Introduction

Aceh Besar west coast is one of the beaches on the west coast of Aceh Besar Regency located in the Aceh Province, tip of Sumatra Island, Indonesia. Aceh Besar Regency consists of two coastal locations, namely the north coast of Aceh Besar and the west coast of Aceh Besar [1]. On the coast there is a littoral zone, namely the coastal area that stretches from the lowest limit of tide to the part of the land that is still influenced by waves and tides [2]. The littoral zone includes subtidal and intertidal zones. The intertidal zone is the coastal area located between high tide and low tide, this area represents the transition from ocean conditions to land conditions [3, 4]. Environmental conditions on the intertidal coast are very dynamic because they are influenced by tidal cycles, waves, and currents.

In the intertidal zone of the west coast waters there are many activities of coastal communities in fulfilling livelihoods such as fishing activities, aquaculture, salted fish drying industry and tourism activities. This will increase the pressure on the coastal water environment and will affect sedimentation in the intertidal zone of the beach [5]. The material that is transported in a sedimentation process is sediment [6]. Marine sediments come from land and the results of biological, physical and chemical activities (processes) occur both on

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land and the sea itself, although there is little input from volcanogenic and cosmic sources [7, 8]. According to [9], in addition to natural factors such as currents and waves that can cause sedimentation, the number of human activities around the coast will also affect the characteristics and distribution patterns of sediments in the sea.

The characteristics of sediments in the intertidal zone of coastal waters also have a major effect on biodiversity, because sediments provide a habitat for many marine biota [10]. Changes in sedimentation levels can directly or indirectly affect the survival and diversity of benthic biota [11]. Bottom sediment of waters also determines the physical characteristics, waves, turbidity of waters and as information on marine development [12]. Research on sediment characteristics has been conducted by [13, 14], However, until now there is no information related to the characteristics of sediments in the intertidal zone of the waters of the west coast of Aceh Besar has never been conducted, and this study is important to understand how the physical and chemical conditions of sediments support marine life and affect the overall coastal dynamics.

The purpose of this study is to find out information about the characteristics of sediments found in the intertidal zone of the waters of the West Coast of Aceh Besar. This research is specifically focused on analyzing the physical properties of sediments, such as texture, grain size, and chemical properties of sediments, including pH content, salinity of sediments and organic carbon. Physical properties, such as texture, grain size, play a role in determining the ability of sediments to support the life of benthic organisms, affecting nutrient circulation, as well as the storage capacity of organic matter. Meanwhile, chemical properties, such as pH content, salinity of sediments and organic carbon, reflect the environmental qualities that support the growth of organisms, including microorganisms, and fauna. This research can be used as a reference in further research and policy formulation related to conservation and rehabilitation of the intertidal area.

2 Materials and methods

The study was conducted in May - June 2024. Sediment sampling was conducted horizontally in the intertidal zone of the west coast of Aceh Besar. The method used in this study is a survey method, which is carried out in the field directly to collect data and samples. Sediment sampling consisted of 4 stations based on activities that produced different impacts on sediments in the aquatic environment (Fig. 1), station 1 is the water area where there are fishing activities, station 2 there are floating net cages, station 3 is an area of salted fish drying industry and station 4 is an area close to shrimp ponds.

Materials used in study this is sample sediment from the West coast of Aceh Besar. The sediment samples that were measured indirectly (ex-situ) were then brought to the soil and plants research laboratory in the Faculty Agriculture at Syiah Kuala University to analyze the sediment texture, organic carbon, pH and sediment salinity.

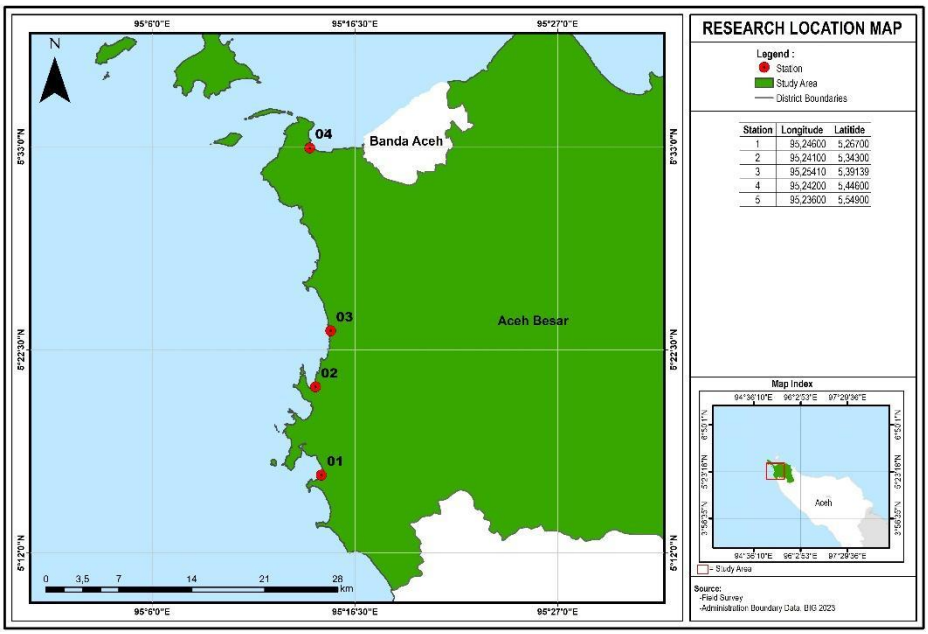


Fig. 1. Map of study area.

2.1 Sediment sampling

Sediment sampling in the intertidal zone of the west coast of Aceh Besar was carried out by using a shovel from the surface to a depth of 20-30 cm. There were five plots at each station, each plots was then composited into one sample bag of 500 grams. Then the sediment samples that have been taken are put into the labeled sample bags and then analyzed for sediment texture and its percentage.

2.2 Sediment fraction

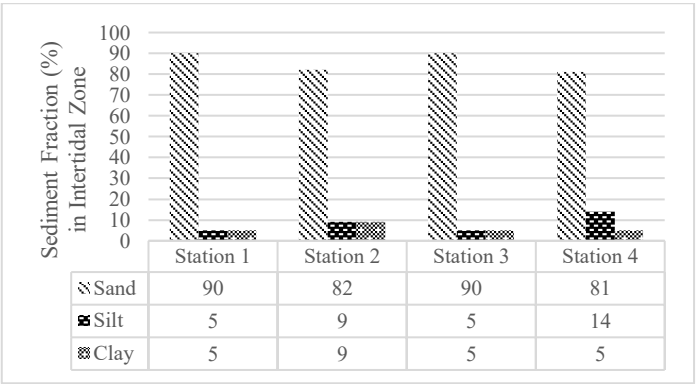
Sediment taken from the research location is used for the analysis of sediment texture. The analysis stages follow [15], using the multistage sieving/filtering method to obtain 1-4 and the pipette method to obtain 5-7. Classification of sediment fractions was based on the proportion of gravel, sand and clay particles. The content of the particle was then plotted base on the percentage values into Sheppard's Triangle.

3 Results and discussion

3.1 Sediment fraction

Sediment texture can be determined by combining the percentages of sand, silt and clay [16]. The results of sediment analysis in the intertidal zone of the west coast waters of Aceh Besar consisted of 3 sediment populations; sand, silt and clay (Fig. 2). The percentage of sand fraction in the study location is in the range of 81 - 90%. This value indicates a high percentage of sand fraction. Station 1 and station 3 have 90% of sand percentage while station 4 has 81% of sand percentage which is the lowest percentage compared to other stations. The silt fraction ranges from 5 - 14% and the clay fraction ranges from 5 - 9%. The results of the

analysis show a small percentage of silt and clay; therefore, the dominance of existing sediments tends to be coarse (sand). This is caused by sand which has a larger particle size so the transportation of sand sediments is influenced by the magnitude of waves and currents [17]. This is also in line with [18], the distribution of sediment fractions is influenced by waves and currents. In areas with high turbulence, fractions that have macroscopic appearances such as gravel and sand will settle faster than microscopic fractions such as mud. Previous research conducted by [19], showed the same results, that the intertidal area of Ujung Pancu beach was dominated by sand. Some studies also showed that the percentage of sand fraction is higher than silt and clay in the coastal intertidal zone [20, 21, 22].



	Station 1	Station 2	Station 3	Station 4
Sand	90	82	90	81
Silt	5	9	5	14
Clay	5	9	5	5

Fig. 2. Sediment fraction (%) in intertidal zone.

In the intertidal zone, high waves can transport larger fractions such as sand [18], while finer fractions tend to be suspended and carried by currents to deeper or calmer waters. Sand has a higher settling velocity due to its weight and larger particle size, so it dominates sediments in tidal areas. In contrast, the fine fraction is transported in suspension while the coarse fraction is transported near the seabed [23, 24]. Furthermore, larger particles settle faster than the small ones [25].

Sedimentation processes create a heterogeneous distribution of sediment fractions, where sand predominates in open shallow marine environments, while fine fractions such as silt and clay are more prevalent in areas with calmer currents and natural protection [18]. Sand has greater resistance to erosion than fine fractions such as silt and clay [26] because fine fractions tend to be carried away by currents. Deeper waters and areas with low currents allow fine fractions such as silt and clay to settle [27]. Therefore, the fine fraction cannot survive in the tidal area, which is a dynamic region and accumulates in quieter areas [28]. This phenomenon explains the distribution of coarser sediment fractions (sand) in coastal areas and finer sediments in deeper or sheltered waters. The sediment fraction is also related to the percentage of carbon. The size of the sediment grains, the sediment formation process, and the sedimentation environment are the main factors that affect the organic carbon content in the sediment. Coarse sediments (sand) have a smaller surface area so that the ability to absorb organic matter is lower. Meanwhile, fine sediments (clay) have a larger surface area so that they are able to absorb and retain more organic matter. This is because fine particles have many small pores that can be where organic matter attaches [29].

Table 1. Sediment texture analysis results.

Sediment Texture	Station			
	1	**2**	**3**	**4**
	Sand	Sandy Loam	Sand	Sandy Loam

According to the results of sediment texture (Table 1), station 1 and station 3 have sand sediment texture and at stations 2 and 4 have sandy loam sediment texture. The things that cause different types of sediment are differences in sediment grains, sources of sediment materials, topography and sediment transport mechanisms. This is in agreement with [30] that the physical properties of soil depend on the number, size, composition and mineral composition of soil particles, pores as well as the ratio of water and air occupying the pores at any given time. Stations 1 and 3 have sand sediment because it is located in open water, so the ocean current is strong enough and the wind that blows strong enough causes the stirring of the bottom sediment to then be transported and settle in an environment, so that the level of sedimentation is higher [31]. Meanwhile, stations 2 and 4 have sandy clay sediments. At this station, the waters are calmer than at stations 1 and 3 which have a type of sand sediment. Sediment texture are always dynamic and changing. According to [32], the changes that occur in waters are caused by physical, chemical, and biological processes that occur in nature. But what may be very influential is the physical process, which is the process of stirring and deposition which is strongly influenced by environmental conditions such as currents and waves [33]. The magnitude of the wave will affect the process of settling or sedimentation rate and also affect the size of sediment grains deposited on the bottom of the water [18].

3.2 Organic carbon in sediment

The content of organic carbon plays an important role as the main source of nutrients for benthic biota that live in sediments [28]. With sufficient organic matter, the intertidal zone ecosystem becomes more fertile and supports high biological productivity [34]. However, if the organic matter content is excessive, it will lead to too high fertility conditions [35]. This excessive fertility will cause eutrophication or high levels of nutrients in the waters that will disturb organisms or biota in the habitat [36]. The results of organic carbon analysis at the research site can be seen in Fig. 3.

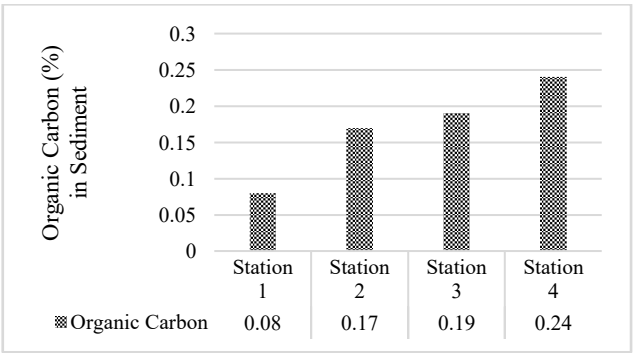


Fig. 3. Organic carbon (%) in sediments of the intertidal zone.

The content of organic carbon at the study site ranged from 0.08 - 0.24% which is classified as low. Organic carbon in the sediment showed the highest results at station 4 which

is 0.24% which is an area close to shrimp ponds. Waste from shrimp ponds can indirectly affect the increase in organic carbon content in sediments [25]. At station 1 there are fishing activities that have the lowest content of organic carbon which is 0.08%. However, the overall content of organic carbon at the study site was low. This is due to the absence of vegetation at the research station. According to [37] organic carbon is produced more in areas covered by vegetation such as mangrove plants. Another cause is the type of sediment at the research station has a high percentage of sand fraction. The content of organic material is influenced by the type of sediment [25]. This is because sandy sediments do not have tight pores, so they are unable to absorb organic carbon which is then easily carried away by the current. Silt and clay substrates have smaller pores, so organic carbon is more easily deposited [38, 39].

According to [29] organic material increases as clay and clay content increase. Fine sediments have a higher percentage of organic material than coarse substrates. This is also influenced by environmental conditions, where a calm environment allows silt deposition followed by accumulation of organic matter to the bottom of the water. On the contrary, in coarse sediments, the content of organic material is low because the finer particles do not settle [40].

3.3 Salinity and pH of sediment

Sediment salinity describes the level of salt contained in the sediment, this salt level can affect the physical properties of the sediment and sediment parameters such as sediment texture and pH [16]. The results of sediment salinity results ranged from 4.0 - 6.5 ppt (Fig. 4). This indicates that the sediment contains high salinity. The study was conducted in a coastal area affected by tides. The salinity value will be greater the further towards the coast or the river that empties into the sea [41], the farther away from the coastline, the lower the salinity level of the sediment [42].

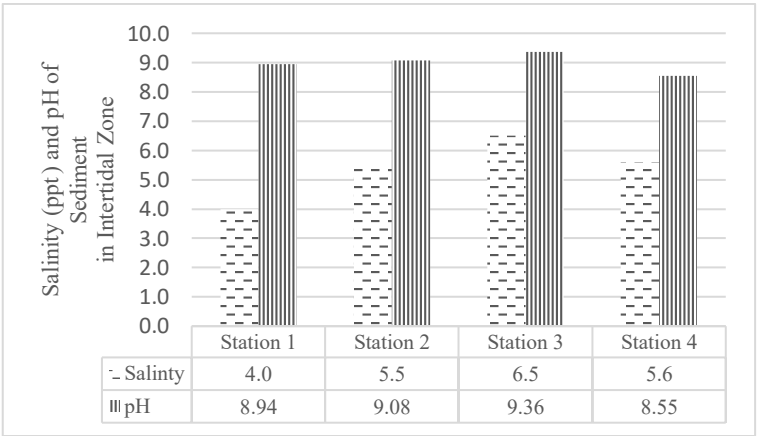


Fig. 4. Salinity (ppt) and pH of sediment in the intertidal zone.

The level of availability of macro and micro nutrients in the sediment can be described by soil acidity (pH). Soil acidity can be influenced by rainfall, vegetation, and liming [43]. The pH of sediment values at the research station ranged from 8.55 - 9.36. This value indicates sediments that tend to be alkaline at each research location. The most optimal pH level is neutral with a value of 6.6 - 7.5, neutral pH is easy for plants to absorb nutrients [16]. The pH value of the soil indicates soil fertility, which indicates the availability of nutrients in the soil [44].

3 Conclusion

Sediment texture found in the intertidal zone of the west coast waters of Aceh Besar are sandy and sandy loam. The sediment fraction obtained is dominated by the sand fraction with a percentage of 81-90%. The content of organic in sediments is in the low category ranging from 0.08 - 0.24%. The salinity value of sediment shows high salinity results (2.56 - 4.16 ppt) and the pH value of sediment in the intertidal zone shows alkaline pH category at each study station (8.55 - 9.36). Overall, the combination of sandy texture, low organic carbon content, moderate salinity, and alkaline pH provides an idea of the intertidal zone ecosystem on the west coast of Aceh Besar that tends to have low fertility and supports the life of certain species that have adapted to these environmental conditions. The ecological implications include the diversity of species typical of these zones, limited productivity potential, and the sensitivity of ecosystems to environmental changes, such as increased organic matter inputs or changes in pH due to human activities.

Based on the characteristics of the sediments found, periodic monitoring of sediment quality, such as organic matter content, salinity, and pH, needs to be carried out to detect environmental changes due to human activities. The rehabilitation of intertidal ecosystems through the planting of coastal vegetation can help stabilize sedimentary conditions and improve ecosystem sustainability. Further studies also need to be carried out to deepen the understanding of the impact of human activities on sediments, so that sustainable management policies can be designed based on scientific data.

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