Granulometric analysis of Lampuuk-Lhoknga Beach, Aceh Province

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Abstract. This research focuses on the granulometric analysis of coastal sediments zone in Lampuuk-Lhoknga Beach, Aceh Province. A total of 11 stations along Lampuuk-Lhoknga Beach located in swash zone are determined as locations for data collection. The sample sediment was collected in November 2018. The selected station was divided into two zones namely the upper swash zone (USZ) and lower swash zone (LSZ). The sampling technique was carried out by using a vertical coring method in order to get a sediment layer with a thickness of 5 cm from the surface. Each sediment sample was wetly sieved to obtain a weight distribution percentage based on the sieve size. Sediment statistical analysis of each sample was based on the Folk and Ward Method. The results of the study show that the average conditions of Lampuuk sediment in the upper swash zone are medium sand; Moderately Well Sorted; Symmetrical; and Mesokurtic. In addition, at the lower swash zone is found a medium sand; Moderately Sorted; Coarse Skewed; and mesokurtic. The beach morphological diversity has resulted in a variation of statistical parameters along the shoreline at Lampuuk and Lhoknga.

1. Introduction
The sediments granulometry analysis may reflect depositional and transportation processes in a coastal area [1]–[3]. The information about the origin, transport mechanism and sediment deposition environment can be obtained from the characteristics of the sediment and grain size analysis [4]–[7]. The dynamics of sediments formed on the coast are also related to a number of processes that occur around the area such as currents, tides, and waves [8]–[10].

Lampuuk Beach is located on the northwest tip of Sumatra Island, Indonesia. It is administratively located in the district of Aceh Besar, Aceh province. Lampuuk Beach is surrounded by the Indian Ocean on the west. This beach is known as a recreational area and also an area that was severely affected by the powerful tsunami in 2004. Preliminary observations that have been made indicate that the Lampuuk beach has brightly colored sandy sediments that show silica content.

The assessment of the granulometry sediments on the Lampuuk Lhoknga Beach is essential to be conducted as the results of coastal system provides various functions including absorption of wave energy,
siltation, and for recreational activities [11]. This research focus on granulometry sediment investigation based upon spatio-temporal analysis on the coast of Lampuuk-Lhoknga.

2. The Methods
Sediment samples were collected from 11 selected stations, particularly stationed from Lampuuk and Lhoknga beach (Fig. 1). Each station has two repetition of data collection, it is representing the upper swash zone (USZ) and lower swash zone (LSZ) areas. So there is a total 22 samples has been collected along the beach. The samples were collected using a PVC tube within sampling depth of 5cm. The sampling location has been recorded using the global position system (GPS).

![RESEARCH LOCATION OF SEDIMENT SAMPLING](image)

**Figure 1.** The sediment sampling station is located at Lampuuk-Lhoknga village, Aceh Besar District.

The sediment samples are carried out using the wet sieve method in the laboratory. There are seven grade levels of sieves are used to separate each sample based on the size of the sieve, i.e. 2mm, 1mm, 0.5mm, 0.25mm, 0.125mm, 0.063mm, 0.038mm, and pan at the bottom. each sample is sun dried to remove their moisture content. Dry weight of each sediment fraction was calculated using digital scales.

Gradistat software [12] has been used to obtain parameters of sediment statistics such as mean grain size, standard deviation or sorting value, asymmetrical or skewness value, and kurtosis or peakedness of distribution curve. Analysis of each sediment statistical parameter based on the Folk and Ward original method [13] based on logarithmic scale (phi).

3. Result and Discussion
The results of granulometric analysis of sample sediments have been sorted based on different size classes. The results obtained from eleven stations showed the presence of a fairly dominant sand fraction.
The medium sand fraction has the highest number of averages in the USZ area, which is 49.39% while the LSZ finds the fine sand with the highest average of 49.96%.

Figure 2. Percentage USZ (a) LSZ (b)

The highest amount of gravel (2mm) fraction is found in the LSZ area of station 6 (17.82%) and station 7 (5.32%), which also contributes to the formation of a bimodal distribution curve. In addition, the other stations form a unimodal curve with only a gravel fraction in small amount (<1%). Furthermore, the mud fraction is also found in very small amounts at each station. Based on the composition of the mud-sand-
gravel obtained from each station, the type of sediment texture is: Sand, Slightly Gravelly Sand, and Gravelly Sand (Table 1).

Table 1. Tipe dan tekstur sedimen pada pantai Lampuuk-Lhoknga

| St. | Sample Type | Textural Group | Sample Type | Textural Group |
|-----|-------------|----------------|-------------|----------------|
| 1   | Unimodal, Moderately Sorted | Slightly Gravelly Sand | Unimodal, Moderately Sorted | Slightly Gravelly Sand |
| 2   | Unimodal, Moderately Sorted | Slightly Gravelly Sand | Unimodal, Moderately Sorted | Slightly Gravelly Sand |
| 3   | Unimodal, Moderately Well Sorted | Slightly Gravelly Sand | Unimodal, Moderately Well Sorted | Slightly Gravelly Sand |
| 4   | Unimodal, Moderately Sorted | Slightly Gravelly Sand | Unimodal, Moderately Sorted | Sand |
| 5   | Unimodal, Moderately Well Sorted | Slightly Gravelly Sand | Bimodal, Poorly Sorted | Slightly Gravelly Sand |
| 6   | Unimodal, Moderately Sorted | Slightly Gravelly Sand | Bimodal, Poorly Sorted | Gravelly Sand |
| 7   | Unimodal, Moderately Well Sorted | Sand | Unimodal, Poorly Sorted | Gravelly Sand |
| 8   | Unimodal, Moderately Well Sorted | Sand | Unimodal, Moderately Sorted | Slightly Gravelly Sand |
| 9   | Unimodal, Moderately Well Sorted | Sand | Unimodal, Moderately Well Sorted | Slightly Gravelly Sand |
| 10  | Unimodal, Moderately Well Sorted | Sand | Unimodal, Moderately Sorted | Slightly Gravelly Sand |
| 11  | Unimodal, Moderately Well Sorted | Sand | Unimodal, Moderately Sorted | Sand |

The sediment statistics value was obtained by calculating the mean grain size, sorting, skewness, and kurtosis parameters from each station i.e. USZ and LSZ, respectively (Figure 3). The sample sediments along the shore showed a wide variation in textural characteristics. The average value for each parameter obtained from all stations especially at USZ contain medium sand, moderately well sorted, symmetrical, and mesokurtic. Meanwhile, the sedimentary conditions at LSZ contain medium sand, moderately sorted, coarse skewed and mesokurtic.

The grain size distribution of sediment is a function of the hydrodynamic conditions. The characteristic of sediment in an area determined by the presence of complex interactions from sediment sources, wave energy levels, longshore current, tidal and coastal construction. The highest number of fine-sand fractions is found in LSZ. It is lead to LSZ generate finer-sized granules than USZ, although both of them from USZ and LSZ had textural similarities contain of sand medium.
Figure 3. The sediment sampling station is located at Lampuuk-Lhoknga village, Aceh Besar District.
Commonly upper part of swash zone (USZ) is only exposed to smaller energy or residual from wave energy, while there are more frequent interactions and exposure to wave action for LSZ, which has produced sediments with more diverse sizes at LSZ. We suspect that this has led to a lower sorting value at USZ than LSZ. Variations formed during and after tides, are expected to encourage sorting of grains on LSZ to be poorer. High energy exposure from this wave also pushes the curve on the LSZ to be coarse skewed.

The abundance of gravel at the LSZ especially at stations 6 and 7 with a large number result in poor sorting condition and a negatively skewed curve. The appearance of gravel at stations 6 and 7 gives an indication of higher energy in the area where it can be seen from field observations that the area is often used for surfing area as the recreational activity due to it has high waves.

4. Conclusion
Statistical parameters of sediments grain size along Lampuuk and Lhoknga Beaches provide an overview of the conditions formed in that area, specifically around station 6, which its sediment has coarse texture and poorly sorted. LSZ has sediment with coarse skewed conditions while symmetrical is found at USZ.

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