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Characteristics and Mineral Content of Sediment at Muara Pulau Kayu(MPK) of Southwest Aceh District

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Abstract- Study on sediment characteristics and mineral content at Muara Pulau Kayu (MPK) of Southwest Aceh District was conducted to find general description of grain size and mineral content regarding to hydro-oceanographic process. Sampling was collected at MPK, Southwest Aceh District during March 2016. Purposive sampling method was used to determine four sampling sites covering the estuary and the beach areas. Grain size and mineral content were analyzed using a set of sieves and X-Ray Fluorescence (XRF with standard reference mineral). Observation on the grain roundness and spherical showed that sediment grains are generally more rounded at the beach area. Mineral content at MPK are dominated by Si, Fe, K, Ca and Ti, and are categorized into volcanic minerals which determining the sediment at MPK originated from Mount Leuser which was an active volcano in the past.

Keywords: Grain size; XRF; Mineral content; Muara Pulau Kayu

Introduction

Sediment is composed of various elements such as Si, C, S and other materials which are formed by chemical, physical, and biological processes (Saniah *at al* ., 2015). Grain size is one of the fundamental properties of sediment particles (Purnawan *at al* ., 2015a). The dynamics of sediment contain information on various geomorphic processes over a landscape (Purnawan *at al* ., 2016). Basic information of sediment in an aquatic area can be obtained from quantitative method (Liu *at al*., 2000). Moreover, sediment fingerprinting provides more information, both spatial and temporal of sediment transport (D'haen *at al*., 2012; Sundararajan *at al* ., 2000). The analysis of sediment provenance employs various parameters to give information about depositional condition and transport history, specifically the utilization of both quantitative and qualitative methods on specific tracer properties to determine the source of sediment (Motha *at al*., 2002; Collins and Walaling, 2002). Though the analysis of the origin of the sediment requires more information in addition to composition and grain size, we also use the particle shape.

Sediment is known to be deposited in estuary through fluvial processes from river stream, coastal erosion and oceanic sediment. Based on earlier information, sediment at Muara Pulau Kayu (MPK) area of Southwest Aceh District contains magnetite. The objective of this study is to describe the characteristic of the sediment and the mineral content at MPK, whereas the magnetite was processed further to analyze the sediment distribution process.

Materials and Methods

A number of sample was conducted at MPK of Southwest Aceh District during March 2016. Sampling sites were determined by purposive random sampling method to represent the area covering the estuary and the beach, which is located in the intertidal zone (Figure 1).

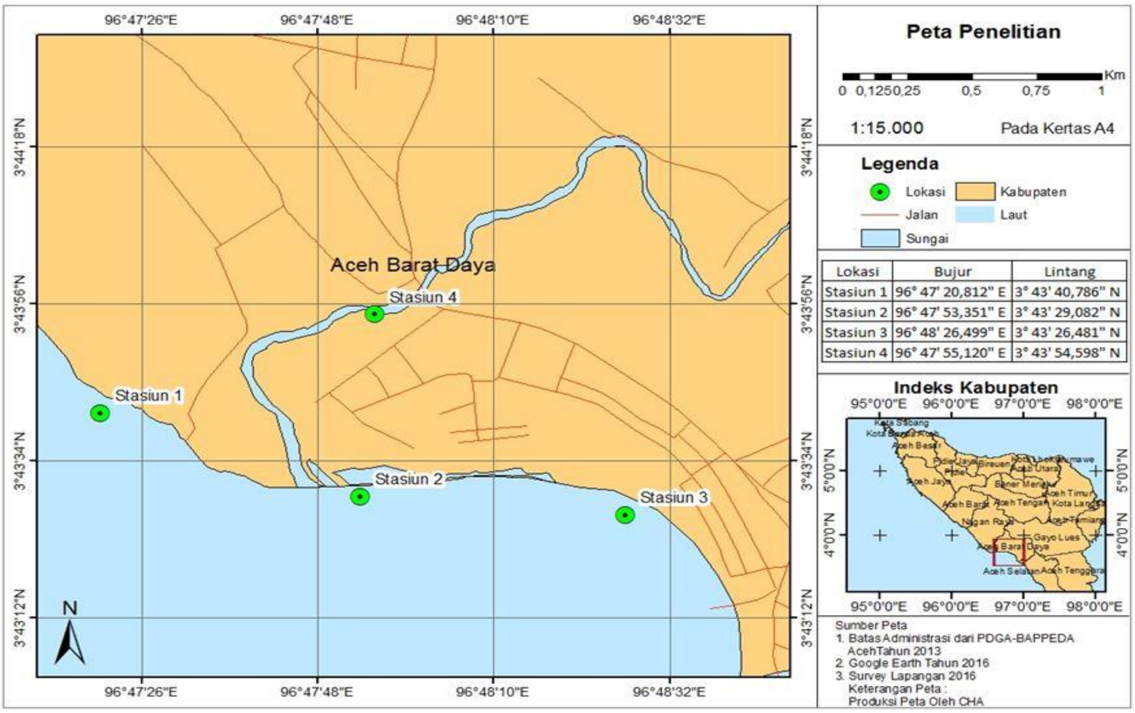

Figure 1.Research Location Map.

PVC pipe with a diameter of 3 inches were used to collect samples vertically to the depth of 30cm from the surface. Bulk of sample was stirred to obtain a homogenous mix. The analysis of the sample was intended to examine the mineral content, grain shape, and mean grain size.

Mineral content analysis was conducted using X-Ray Fluorescence Spectrometer (XRF) in the Central Laboratory of Advance Mineral and Material, Natural Science Department, State University of Malang. Grain shape analysis was conducted to describe how far the sample has been transported from its origin. Iron grain shape analysis was conducted by using a microscope to observe the grain physical properties, i.e., Roundness (R) and Spherical (S). The description of the shape of sediment grain refers to Dyer (1986). The wet sieve technique is the method used to obtain grain size values. Sieved sample is separated according to its grain size. The amount of the sediment left in the sieve was then turned into fraction weight percentage that is used to obtain mean grain size (d) as given in the following expression:

$$d = \sum \frac{f\ m}{100} \qquad (1)$$

Where:
f = frequency in percent for each size class
m= mesh size (mm)

Results and Discussion

Grain size and particle shape

Types of sediments in the entire station are classified as sandy sediment. Grain in the beach area (station 1-3) is rougher than in the estuary (station 4). Fraction of fine sand (0.125mm) was the highest at three stations i.e: station 1, 2, and 3, meanwhile station 2 shows medium sand (0.25mm) in dominant. The grain size distribution is presented in Table 1.

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Table 1. Sediment Grain Size at MPK

St.	Weight percentage (%)							(d) (mm)	Sediment type
	2 mm	1 mm	0.50 mm	0.25 mm	0.125 mm	0.063 mm	0.038 mm		
1	0	0.41	29.87	33.25	**35.23**	1.24	0	0.28	Sand
2	0	0	3.09	**54.05**	39.51	3.35	0	0.20	Sand
3	0	0.38	6.69	28.93	**60.57**	3.43	0	0.18	Sand
4	0	0	2.02	26.06	**50.76**	19.27	1.89	0.15	Sand

Observation on the sediment grains using microscope show varying particle shapes. Iron particles at stations 1, 2 and 3 show high values of roundness (R) and spherical (S), while the less spherical shape was found at station 4 despite showing a finer roundness. The roundness and spherical values are shown in Figure 2 and 3.

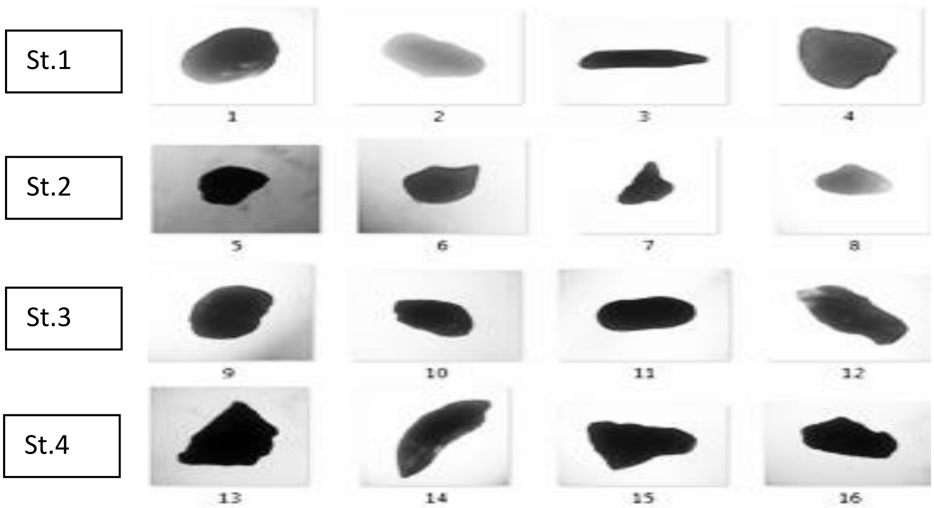

Figure 2. Roundness (R) and Spherical (S) value for sediment particles with >0.25 mm in size; 1(R0.9/S0.7), 2(R0.7/S0.5), 3(R0.7/S0.3), 4(R0.5/S0.7), 5(R0.5/S0.7), 6(R0.7/S0.7), 7(R0.3/S0.5), 8(R0.7/S0.7), 9(R0.7/S0.9), 10(R0.9/S0.5), 11(R0.9/S.0.5), 12(R0.5/S0.5), 13(R0.3/S0.7), 14(R0.5/S0.3), 15(R0.3/S0.3), 16(R0.3/S0.5).

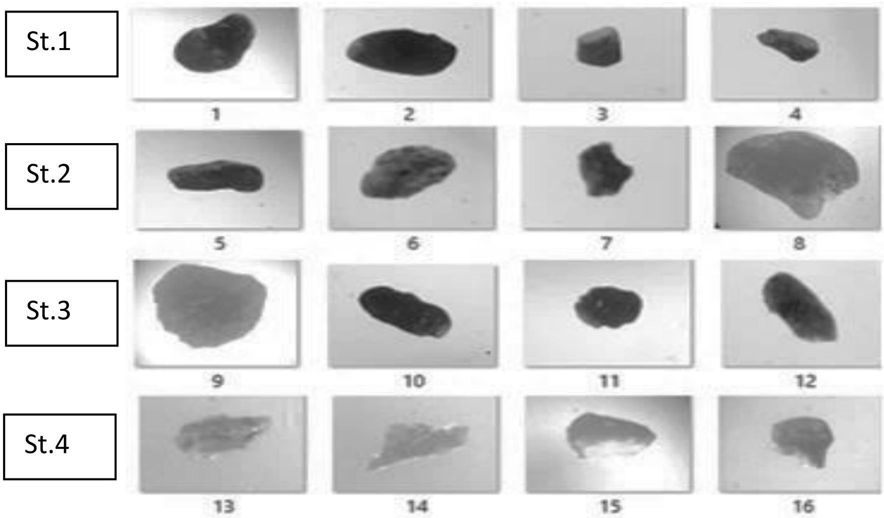

Figure 3. Roundness (R) and Spherical (S) value for sediment particles with <0.25 mm in size. 1(R0.9/S0.7), 2(R0.9/S0.5), 3(R0.3/S0.9), 4(R0.5/S0.9), 5(R0.7/S0.3), 6(R0.9/S0.7), 7(R0.3/S0.7), 8(R0.7/S0.9), 9(R0.9/S0.9), 10(R0.9/S0.5), 11(R0.5/S.0.9), 12(R0.7/S0.5), 13(R0.5/S0.5), 14(R0.1/S0.5), 15(R0.5/S0.7), 16(R0.3/S0.7).

Mineral Content

X-ray Fluorescence (XRF) test shows that silica (Si) was found as the most abundant element at station 1, 2, and 3 followed by iron (Fe), potassium (K), and calcium (Ca). While station 4 found iron as the highest proportion (38.4%) followed by silica with 34.6%. The small amount of minerals e.g., Ti, Cr, Mn, Ni, Zn, Cu, Rb, Eu, Re and Yb were also found at all stations.

Table 2. Sediment Mineral Content at MPK

Mineral	Concentration (%)			
	St. 1	St. 2	St. 3	St. 4
Si	**59.7**	**55.0**	**49.9**	34.6
Fe	22.1	22.5	26.5	**38.4**
K	9.26	8.40	9.27	8.35
Ca	5.23	5.30	4.85	3.29
Ti	1.76	1.49	1.67	2.55
Mn	0.46	0.70	0.60	0.68
V	0.06	0.070	0.072	0.105
Rb	0.37	0.36	0.46	0.50
Ni	0.33	0.27	0.34	0.26
Cu	0.19	0.16	0.19	0.21
Cr	0.14	0.12	0.12	0.12
Eu	0.4	0.3	0.3	0.50
Zn	0	0.04	0.06	0.1
Sr	0	0.50	0.60	0
Re	0	0.2	0.2	0.2
Al	0	6.9	7.0	9.4
Ba	0	0.1	0.2	0
P	0	0	0	0.63
Yb	0	0.03	0	0.04

Discussion

The sediment types at all stations were classified as sandy, as the finest grain size (d) was found at station 4 that is located in the estuary area. The difference in mean grain size is associated with an energy level at depositional environment. The fine sediment grain tends to be found in the estuary area,in general relatively weak current conditions occurred, thus allowing the deposition of smaller particles (Purnawan *at al* ., 2012). While in coastal areas (stations 1-3) show coarser size, resulting from more energy interactions in those areas, in particular as a result of wave and tidal exposure (Curtiss *at al* ., 2009; Purnawan *at al* ., 2015b).

The highest Silica (Si) mineral found by XRF examination is consistent with Shaffer (2006) who confirmed Si is major component found intertriginous sediment. Fine-grained Silica found on the beach indicates mature sediment and derived from weathering processes which break into smaller pieces and transported by river flow. High amount of silica found on the beach may refer to the typical mafic rock which is associated with high silica content of rock or sediment. When the sediment transport process takes place there is a percentage increase in line with Potassium (K) as a mica mineral. Meanwhile carbonate (Ca) derived from marine organism activities was found to spread across the shoreline and the composition of Ca were decreased along the upstream (Boggs, 2009). The presence of Silica (Si), Magnetite (Fe), Potassium (K) and Titanium (Ti) is likely to be originated from past volcanic activity. Sudaryo and Sutjipto (2009) found out that minerals contained in the Mount of Merapi volcanic ash composed of 54.56% of silicon dioxide (SiO_2), 18.37% of aluminum oxide (Al_2O_3), 18.59% of iron oxide (Fe_2O_3), and 8.33% of calcium oxide (CaO). The similarity between the mineral content at MPK and volcanic ash suggests that sediments of MPK might originated from Mount Leuser, an active volcano in the past, which further makes the sediments to be deposited in the river stream (station 4) and spread across the beach area (station 1, 2, and 3).

The higher Fe mineral is commonly found in sediment with relatively fine grain size (Armstrong-Altrin *at al* ., 2014). In this research, the highest magnetite concentration (38.4%) was found in the estuary (station 4) that also show the smallest mean grain size. Meanwhile the magnetite (Fe) concentration at station 1, 2, and 3 range between 22.1 and 26.5%. Ti is also found with smaller concentrations vary from 1.49 to 2.55% coinciding with the decreasing proportion of Fe since the occurrence of Ti is commonly found in the form of titanomagnetic materials which is the combination of Fe and Ti (Pearce *at al* ., 2012). The presence of magnetite (Fe)at sediment is suspected to be originated from terrigenous sediment resulting from volcanic debris around sampling location that is transported through fluvial processes.

The separation of magnetite granules with size less than 0.25 and greater than 0.25 show higher roundness and sphericity values at finer grain-size. At both sizes (i.e. <0.25 and> 0.25), it is found that the particle shape at foreshore (e.g., Stations 1, 2, and 3) are marked by high values of roundness and spherical compared to station 4. Magnetic (Fe) grain at foreshore might have been transported to the downstream through fluvial processes that occurred for a long period thus it may lead the grain to be more rounded. According to Sundarajan *at al* . (2010) the higher the spherical and roundness of a particle, the further it has been transported from the parent source rock. The statement agrees with Friedman and Sanders (1978) who identified that particle shape is the result of abrasion during transport leading the angular shape of its corner to reduce.

Conclusions

The highest average grain size of sediment at MPK was found at station 1 in the beach area while the lowest was found at station 4 in the estuary area with average size of 0.281 mm and 0.151 mm, respectively. Grain magnetite-contained is well-matured in the beach area instead of the estuary. XRF test indicated that the main compositions of mineral at MPK are Si, Fe, K and Ca followed by little amount minerals of Ti, Cr, Mn, Ni, Zn, Cu, Rb, Eu, Re and Yb. The study concluded that the mineral content in MPK sediments is likely to be generated from past volcanic processes of Mount Leuser.

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