Mineral Analysis and Physical Characteristics of Beach Sands in Latuhalat and Suli Village to Support the Beach Geotourism of the Maluku Province

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Abstract. From the aspect of the earth, the Maluku islands are a unique formation. Because Maluku is at the confluence of four world plates (Indo-Australian plate, Pacific plate, Philippine sea plate and Eurasian plate) so it has an interesting geological structure. One of unique formation is having thousands of islands with charming white sand beaches. White sand beaches are part of the geotourism diversity in Maluku, so research is conducted at Latuhalat (Santai and Namalatu beaches) and Suli (Natsepa beach) which aim to identify the shape and size of beach sand, analyze mineral content using the X-RD and X-RF methods. The results showed the shape of sand grains in the Santai and Namalatu beaches of Latuhalat Village were identified as oval-shaped irregularly with an average size of Santai sand grains of 0.12 mm and Namalatu sand of 0.21 mm. While the shape of sand grains in Natsepa beach, Suli Village was identified as spherical with an average grain size of 0.10 mm. Beaches in the three locations are classified as types of sandy beaches (sand sediments) with sandstone rock types. Sand on the Namalatu beach, Santai beach, and Natsepa beach has very fine to medium grain size and contains Aragonite (CaCO\(_3\)) and Quartz (SiO\(_2\)) minerals that are dominant. The shape and size of the grains of sand and its constituent minerals are very good to support the Namalatu and Santai beach geotourism in Latuhalat Village and Natsepa beach in Suli Village.

1. Introduction

As a new type of tourism, geotourism was created to utilize the aesthetic value of landscape on the surface and below the surface of the earth wisely and wisely. This nature-based tour utilizes the non-living aspects of the earth's diversity (geodiversity). The excavation and development of the attraction of the earth phenomenon that compose geotourism is entirely based on a tourism program oriented to accelerating the improvement of the welfare of the local community.

Geological natural resource conservation activities are needed to prevent damage that decreases the meaning and function of its existence (development of science, education, tourism and so on). In the context of geological natural resource management, disaster-prone areas have become important objects that are closely related to mitigation efforts. For this reason, a study of beach sand analysis is needed in the coastal of the research area and its impact as well as planning to maximize the geological benefits in life, especially for coastal geotourism activities.
2. Experimentals

2.1. Research areas
There are three locations used as research areas, namely the location of Natsepa beach in Suli Village and Namalatu beach and Santai beach in Latuhalat Village, as shown in Fig.1. Sand sampling was carried out in the three research areas. Laboratory measurements were carried out to obtain the shape and size of the grains of sand, while to obtain the type of sand mineral and the percentage of dominant elements used geochemical methods namely the XR-D (X-Ray Diffraction) and XR-F (X-Ray Fluorescence) methods.

![Topographic map of the research area](image)

**Figure 1.** Topographic map of the research area

2.2. Data acquisition
Field data collection was carried out at all three locations, starting with tracking coordinate data and measuring the geometry of the stretch of the beach and sand sampling. The length of the coastline can be increased or reduced based on the survey location or according to the target information on the availability of beach sand. Field data acquisition as follows:
- Field measurement data, in the form of tracking coordinate data for each coordinate point (Tk1, Tk2, Tk3, ……, TkN), coastline length (L), coastline width (w1, w2, ……, wN) and coastline slope (S1, S2, ……, SN).
- Sampling is done with the sampling point is in the intertidal zone at each location, then the coordinates of the points are measured. A 3-inch paralon pipe is used to take samples vertically with a layer thickness of 30 cm from the surface.

2.3. Field data processing
The steps in processing the data are based on field measurements and laboratory measurements of sand samples.
  a. Processing field data
     • Contour maps are made at each observation location.
     • Depicting coastlines according to measurement data.
  b. Processing sand samples from laboratory measurements
     • Samples that have been taken are then stirred until they are evenly distributed, after which they are weighed using an analytical balance weighing 100 grams and (3x500) grams. A total of 500 grams of samples are used for analysis of sediment fractions, 100 grams are used to
observe grain form, while analysis of mineral content using XR-D and XR-F requires about 500 grams of sand samples.

- Calculation of grain size based on the analysis of sediment fraction using the wet sieving method. Sand sifting samples use a stratified filter to separate the sediment grains based on the grain size fraction, in order to obtain an average grain size diameter of the sand using the equation [1], as follows:

\[
d = \frac{\sum \% \text{of sand mass} \times \text{grainsize}}{100}
\]

where \(d\) = the value of the average grain size (mm). Sand sample weights were weighed using analytical scales [2].

- Observation of the characteristics of the shape of the sand is done using a microscope.

- Analysis of the shape of the sand grains is carried out to find out how far the transport of the sample is from the source rock.

c. Analysis of mineral sand samples

- Analysis of crystallinity with XR-D

Mineral analysis of sand samples by XR-D method is used to determine the elemental composition of a material in the form of mineral content, percentage, and degree of crystallinity of minerals from a sample, so that it can be used to determine the accumulation of diffraction patterns used to determine the arrangement of particles in a solid pattern.

- Elemental analysis of samples with XR-F [3,4].

XR-F method is one of the methods used for the analysis of elements in materials (beach sand) qualitatively and quantitatively. XR-F characterization was carried out on beach sand samples to obtain data in the form of a percentage of elements contained in the samples tested.

3. Results and discussion

3.1. The Shape of beach sand grains

A total of 100 grams of sand at each location was observed visually before the separation process. Furthermore, the separation process (extraction) is observed under a microscope, a significant change in color and shape. Before processing the sand looks slightly brownish than after the separation process (Fig. 1 (b-c), 2 (b-c) and 2 (b-c)). The change in color of the sand indicates a change in mineral content in the beach sand [5]. The shape of beach sand produced by abrasion during transportation, where collisions occur with bedrock so that it changes the shape from angular to rounded. The longer the distance traveled by sand sediment grains, the more complex and more rounder the shape of the sand grains [6,7].

3.2. Size of beach sand grains

Based on the analysis of the coastal sediment fraction, the average diameter of sand grains at Santai beach was 0.12 mm, sand at Namalatu beach was 0.21 mm, and sand at Natsepa beach was 0.10 mm. Coastal sediments are sedimentary material deposited on the beach in the form of sand. So based on the size of the sand grain diameter which is classified according to the Wentworth scale [8], sand on the Namalatu beach is included in the medium sand grain size class, sand on the Santai beach belongs to the fine sand grain size class, and the sand at Natsepa beach is classified in the very fine sand grain size class (Fig. 3).
Figure 2. Color changes in the sand at the three research area. (a) Map of research location tracking results in Google Earth, (b) before the process of extraction of Santai beach sand, (c) after the process of separation of Santai beach sand

Figure 3. Measurement of the mass of sand grains at Santai, Namalatu and Natsepa beaches

3.3. Mineral content in beach sand

The results of qualitative analysis using XR-D on beach sand at the three locations are sand at Santai beach (Figure 4) showing the main mineral content is dominated by aragonite (CaCO$_3$), magnesian calcite (MgCaO$_3$) and quartz (SiO$_2$) and followed by other minerals such as Frondelite (MnFe$_4$(PO$_4$)$_3$(OH)$_5$) and Tschernichite ((Ca, Na)Si$_6$Al$_2$O$_{16}$.8H$_2$O). CaCO$_3$, MgCaO$_3$, and SiO$_2$ are listed on the peaks of the 2θ angle. This is in accordance with research conducted by [9]. CaCO$_3$ has the highest peak found at a diffraction angle of 25.15° with an intensity of 27500 cps and has a dominant frequency. Then followed by SiO$_2$ having the highest peak found at a diffraction angle of 71.20° with an intensity of 18500 cps. High SiO$_2$ and Calcium (Ca) content is found in medium sized sand [10]. There are some coastal areas on Ambon Island that have black sandy beaches, such as research conducted by [11] on the Bantul coast of Yogyakarta.
Figure 4. Spectrum of mineral content in Santai beach sand

Figure 5. Spectrum of mineral content in Namalatu beach sand

Figure 6. Spectrum of mineral content in Natsepa beach sand

The results of quantitative analysis using X-Ray Fluorescence (Table 1) obtained that the content of the dominant element in Santai beach sand was Calcium (Ca) of 89.70% then followed by Silica (Si) of 3.15% and the rest in the form of impurities with some elemental content with the percentage smaller than 2%. The content of the dominant element in Namalatu beach sand contains Calcium (Ca) of 82.80%, followed by Silica (Si) of 7.23% and Magnesium (Mg) of 2.77%, and the remainder is in
the form of impurities with some elemental content whose percentage is smaller than 2%. Furthermore, the dominant element content in Natsepa beach sand contains calcium (Ca) which is quite high at 62.90% then followed by silica (Si) at 21.70%, aluminum (Al) at 4.70%, iron (Fe) at 2.80%, potassium (K) by 2.48%, and the remainder is in the form of impurities with some elemental content whose percentage is smaller than 2%.

With the found high amount of Calcium (Ca) content followed by Silica (Si) resulting in exposure to white sand along the coast. Sand content varies depending on the location of the rock and its condition. The white sand on the coast reflects the presence of Silica elements. The impurity mineral content contained in high calcium sand is the content of impurities carried during the deposition process which can also have a visual effect on the beach sand. The presence of strontium (Sr) in coastal sand is related to the abundance of sediment-forming organisms. Santai and Namalatu beach sand can be said to have a high level of calcium purity because the other elements are less than 15%. This is as stated by [12].

| Name of compound | Percentage of mass% |
|------------------|---------------------|
|                  | Santai Sand | Namalatu Sand | Natsepa Sand |
| Na               | 0.42        | 0.64          | 0.99         |
| Mg               | 1.95        | 2.77          | 1.19         |
| Al               | 0.61        | 1.69          | 4.70         |
| Si               | 3.15        | 7.23          | 21.70        |
| P                | 0.09        | 0.07          | 0.10         |
| S                | 0.31        | 0.33          | 0.44         |
| Cl               | 0.43        | 0.51          | 0.97         |
| K                | 0.17        | 0.41          | 2.48         |
| Ca               | 89.70       | 82.80         | 62.90        |
| Fe               | 1.21        | 1.97          | 2.80         |
| Co               | -           | -             | 0.06         |
| Rb               | -           | -             | 0.04         |
| Sr               | 1.91        | 1.57          | 1.35         |
| W                | -           | -             | 0.24         |

The three research areas have been functioned as beach geotourism for visitors to domestic and foreign tourists over the years. Sand in the three coastal geotourism locations with different colors because it contains more calcium carbonate (CaCO₃) which comes from corals, broken shells and comes from marine animals. So that the sand with CaCO₃ content, besides being used as a place of recreation, sunbathing after bathing, can also be used as health therapy by sunbathing or can lay the body in the sand and cover it up to the neck for several minutes.

4. Conclusion
Based on the results of interpretation and discussion, it can be concluded:

a. The shape of Santai and Namalatu beach sand in Latuhalat Village is identified as oval-shaped irregular with an average size of sand in Santai beach of 0.12 mm and Namalatu sand of 0.21 mm. Whereas the shape of Natsepa beach sand in Suli Village was identified as spherical with
an average grain size of 0.10 mm. Beaches in the three locations are classified as types of sandy beaches (sand sediments) with sandstone rock types.

b. Sand on Namalatu beach, Santai beach, and Natsepa beach have very fine grain size to medium grain size and inside it is dominated by Aragonite (CaCO$_3$) and quartz (SiO$_2$) minerals. The shape and size of the grains of sand and minerals that compose it very well to support the Namalatu and Santai beach geotourism in Latuhalat Village and Natsepa beach in Suli Village.

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