MORPHOLOGICAL CHARACTERISTICS AND MINERAL CONTENT ANALYSIS OF MAGNETIC MINERALS BASED ON RIVER AND COASTAL SAND USING SEM-EDX

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Abstrak

This study aims to analyze the mineral content and morphological characteristics of magnetic minerals based on coastal and river sand. Analysis of minerals content uses Atomic Absorption Spectroscopy (AAS) to determine the content of Fe and Energy Dispersive X-Ray (EDX) to determine the elements of magnetic minerals based on coastal and river sand. While the morphological characteristics were analyzed using Scanning Electron Microscope (SEM). Based on the AAS analysis, magnetic mineral based on coastal sand has higher Fe content (9.03 mg/gram) compared to magnetic mineral based on river sand (8.03 mg/gram). This is also confirmed by EDX analysis where the Fe content of magnetic mineral based on coastal sand is $2.07 \pm 0.21\%$. This value is greater than the Fe content of magnetic mineral based on river sand which cannot be measured by EDX. Morphological analysis using SEM shows that magnetic mineral based on coastal sand has a relatively uniform particle size compared to magnetic mineral based on river sand. The particle size of magnetic minerals based on coastal sand also smaller than magnetic minerals based on river sand. Coastal sand also has finer size compared to river sand. This is because coastal sand sediments are formed due to the energy of sea waves so that they have a smoother structure. While river sand sediments come from limestone deposits that have a fine and coarse structure.

Keywords: magnetic minerals, coastal sand, river sand, AAS, SEM-EDX

Introduction

Indonesia is a country that has the fourth longest coastline in the world [1]. Indonesia also has many rivers. Coastal and rivers have very high iron sand potential [2]. In addition, Indonesia consists of several islands, one of which is Lombok Island in West Nusa Tenggara (NTB). Lombok island has coastline with length of 2,333 km and 4 river lines which have a lot of natural iron sand that has potential to be developed [3].

Iron sand has various minerals content depending on the local source. Iron sand can be classified into three types excavated sand, coastal sand, and river sand [4]. Iron sand consists of Ti, Fe, Si, and Ni generally [5]. The area on Lombok Island which is suspected to have iron sand is the beach and river in the east Lombok area and Mataram [6]. East Lombok has a river that directly flow into the coastal areas like Telindung [7] and Pringgabaya [3]. This coastal and river sand have very black sand, so they are thought to have a high natural iron sand content. However, the use of natural iron sand based on coastal and river in this area is still not optimal because it is only used as a cement mixture [6]. Even though the benefits generated by the minerals found in natural sand are very large if they are used properly.

Natural iron sand contains magnetic minerals such as magnetite (Fe_3O_4) [8-13], hematite (α-Fe_2O_3) as main mineral and maghemite (γ-Fe_2O_3), silica (SiO_2) [5] [14], alumina (Al_2O_3), rutile (TiO_2) and ilmenite ($FeTiO_3$) as minor compounds [15-17]. The difference in mineral content is caused by geological setting and mineralization process in each region. These minerals are 88% magnetic and 12% are non-magnetic [6]. These minerals have good electrical and magnetic characteristics so that they can be used in biomedical field such as heavy metal adsorption [7,18], magnetic sensor and GMR [19].

Morphology is the property of a material on its surface [20,21]. Morphological characterization was carried out using Scanning Electron Microscope (SEM) [22], Atomic Force Microscope (AFM), Scanning Transmission Electron Microscope and Topography Measuring System (TMS) [23]. Morphology of the iron sand synthesized using solid state reaction method tends to be irregular with almost spherical grain shape. The resulting grain size can reach order of nanometers when grinding using high energy milling with a grinding time of 90-120 hours [24].

Previous research on iron sand on the island of Lombok has examined the mineral content of coastal iron sand [2,3,6]. However, not many have investigated the morphological analysis of the iron sand [24,25]. Not many have analyzed comparison of mineral content of coastal and rivers iron sand and the comparison of morphological characteristics of magnetic mineral based on coastal and river sand. The physical properties of material are influenced by its morphology such as dielectricity and conductivity [15,26].
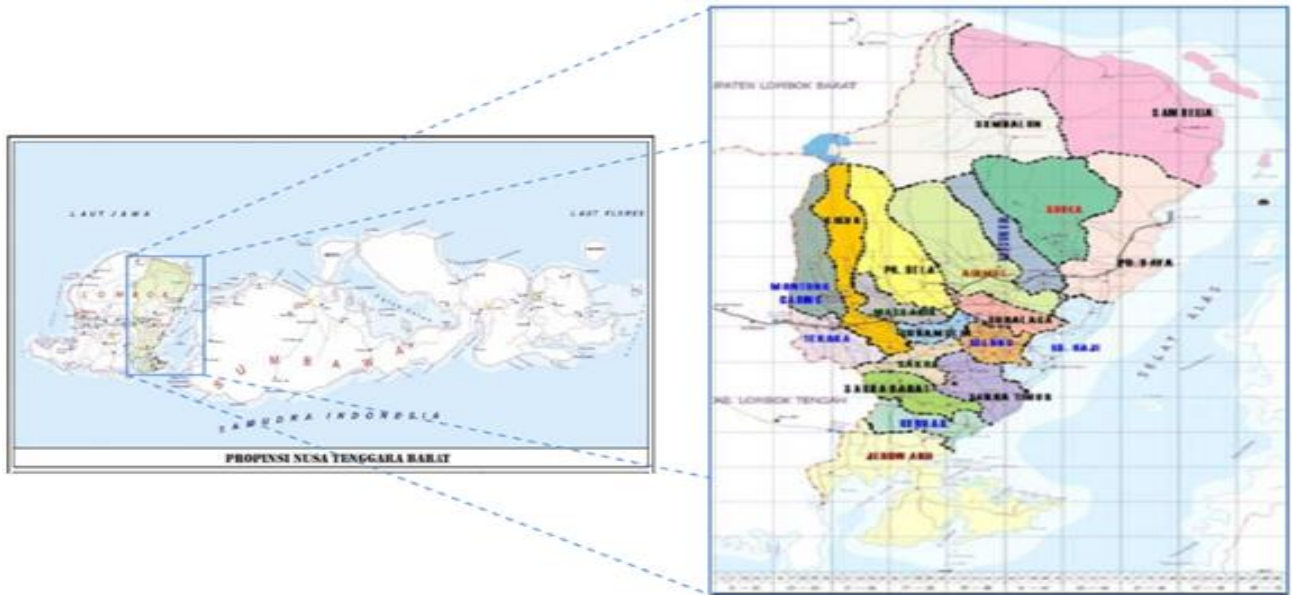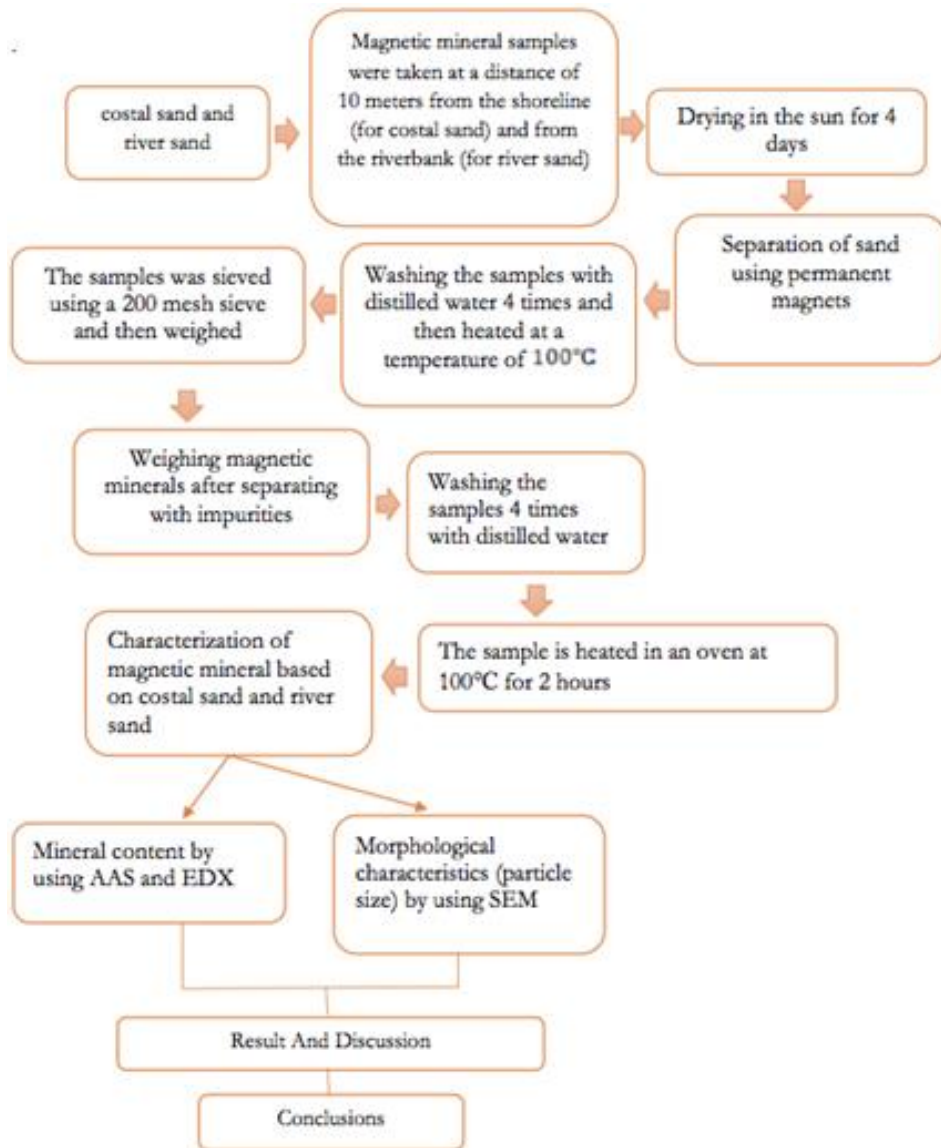
Figure 1. Research location map [27]

Figure 2. Research flowchart

Experimental Method

This study was conducted to determine the characteristics of mineral content and morphology of magnetic minerals based on coastal sand and river sand obtained in the Pringgabaya area, East Lombok Regency. Research location map is shown by Figure 1. Magnetic mineral samples were taken at 10 meters from the shoreline (for coastal sand) and from the riverbank (for river sand [2,7]. Magnetic mineral samples based on coastal sand and river sand then were analyzed at the Physics Laboratory of UIN Mataram for analysis using SEM-EDX, and BPTP NTB for analysis using AAS.

Figure 2 shows a diagram of the research carried out in this study. The iron sand samples were dried in the sun for 4 hours. The iron sand is then weighed in 100 grams of mass and separated from the impurities using a permanent magnet. After the iron sand is obtained, it is then weighed to get the mass of the iron sand sample which the impurities are already removed so that the percentage of the magnetic mineral content from nature is obtained [16]. The sample was then washed using distilled water and filtered using filter paper. The last process of sample synthesis is drying the sample using an oven for 2 hours at a temperature of 100^0C to remove residual distilled water [28].

Morphological characterization of samples was carried out using Scanning Electron Microscope (SEM) Jeol 70 type. This characterization aimed to determine the morphological characteristics of the sample [29,30]. Mineral content was characterized using Energy Dispersive X-Ray Analysis (EDX) which is a complement to SEM. In addition to using EDX, mineral content analysis was also carried out using Atomic Absorption Spectroscopy (AAS) [30].

Result and Discussion

Magnetic minerals based on coastal and rivers natural sand in the Pringgabaya sub-district, East Lombok district contain magnetic minerals. This magnetic mineral is separated using permanent magnets. It aims to separate between magnetic minerals and their impurities [6,14]. The results of the separation of natural sand with impurities are shown in Figure 3.

(a)
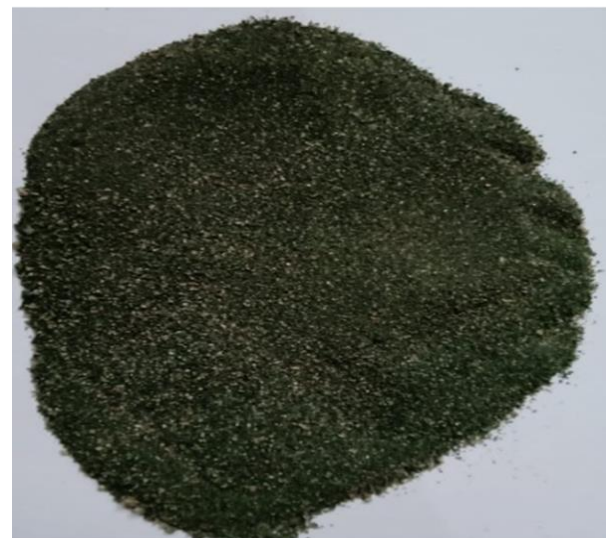
(b)

Figure 3. Natural iron sand after separation using permanent magnets, (a) coastal and (b) river sand

Based on Figure 3, the coastal sand has darker color than the river sand. Coastal sand grains also appear finer when compared to river sand. The darker black color on coastal sand indicates a higher concentration of magnetic minerals compared to river sand. This is depicted by the percentage of magnetic minerals in coastal sand and river sand as shown in Table 1.

Table 1. Percentage of magnetic mineral content in coastal and river sand

No	Sand Type	Mass (gram)		Percentage (%)
		Natural Sand	Magnetic Sand	
1	Coastal Sand	100.015	88.301	88.169
2	River Sand	100.114	62.711	62.639

Based on Table 1, the magnetic mineral content of coastal sand is higher than river sand. This proves that the black color possessed by the sand comes from the magnetic mineral content contained in coastal sand. These results can be used as an initial reference for the use of magnetic minerals based on natural sand as industrial resources. The percentage of magnetic mineral content of East Lombok coastal sand is still higher than Pantai Gading coastal sand in Mataram City which is 85.427% but lower than Ampenan coastal sand which is 96.233% [6]. Magnetic minerals that have been obtained from natural sand are then analyzed for Fe metal content using AAS. The results of the Fe metal content analysis are presented in Table 2.

Table 2. Fe content of magnetic mineral based on coastal sand and river sand analyzed using AAS

No	Sand Type	Fe Content (mg/gram)
1	Coastal Sand	9,03
2	River Sand	8,03

Based on Table 2, magnetic minerals based on coastal sand have a greater Fe content than river sand. However, the Fe content of East Lombok coastal sand is still smaller than the Fe content taken from Mataram city, which is 12.816 mg/gram in Loang Baloq area and 16,277 mg/gram in Ampenan area [6]. After analyzing the Fe content using AAS, the samples were then analyzed using EDX. The results of the mineral content analysis using EDX are shown in Table 3.

Table 3. Characteristics of magnetic mineral content in coastal and river sand analyzed EDX

No	Element	Percentage of element (%)	
		Magnetic mineral based on coastal sand	Magnetic mineral based on river sand
1	C	25,95±0,46	8,40±0,28
2	O	39,47±0,68	48.34±0,61
3	Na	2,09±0,12	2,83±0,12
4	Mg	0,34±0,04	0,44±0,04
5	Al	5,87±0,16	7,44±0,16
6	Si	20,55±0,29	27,56±0,31
7	K	2,19±0,12	3,49±0,14
8	Ca	1,12±0,09	1,25±0,09
9	Ti	0,34±0,06	0,25±0,05
10	Fe	2,07±0,21	-

Based on Table 3, the highest mineral content in coastal sand and river sand is silica. The silica content of coastal sand is (20.55±0.29)% while the silica content of river sand is (27.56±0.31)%. It shows that river sand contains more silica than coastal sand. This can explain that the color of coastal sand is more black than river sand. The black color of the sand is due to the magnetic minerals in the sand such as Fe_2O_3 [3][14]. This is also proven by AAS and EDX analysis. Based on the AAS analysis, coastal sand has higher Fe content which is 9.03 mg/gram compared to river sand which has Fe content of 8.03 mg/gram. This is also confirmed by EDX analysis where the Fe content in coastal sand is 2.07±0.21%. This value is greater than the Fe content in river sand which cannot be measured by EDX.

The difference results of magnetic mineral content between AAS and EDX measurement can be explained as follows. The principle of measuring the content of elements using AAS is measuring the intensity of electromagnetic wave transmitted by liquid sample which is correlated with the intensity of spectrum absorption by the elements contained in the sample and according to Lambert-Beer law correlated with concentration (using a standard solution absorption comparison). This measurement is very specific for each metal element studied (specific to the reference lamp) and this measurement is specific for very dilute concentrations. The AAS measurement is greatly disturbed by the presence of interferences that come from the solution itself and elements that have similar absorptions [31].

The characterization of mineral content in EDX uses characteristic X-rays emitted by secondary electrons. The process is the same as SEM but has a different output. Analysis of the characteristic X-ray radiation emitted by the sample by secondary electrons will produce information about the mineral content in the sample [22][32]. The characteristic X-ray radiation spectrum produced in characterization process using EDX is shown in Figure 4.

The EDX analysis principle is when an electron interacting with the material, then the electron is scattered by other electrons surrounding the atomic nucleus of the material. The scattered electrons are called primary electrons and electrons in orbit will be reflected out of the system, resulting in a vacancy that will be filled by electrons from the outer shell. Because the outer electron has higher energy, when it moves to a lower energy orbit, it releases energy in the form of photons, known as characteristic X-rays. The characteristic X-ray energy spectrum emitted has a specific energy that depends on the atomic number of the material. By knowing the

energy of the characteristic X-rays emitted, it can be known the atomic number of the material that emits the characteristic X-rays and also the relative content of each material. The intensity of the characteristic X-rays reflected as result of EDX analysis shown in Figure 4.
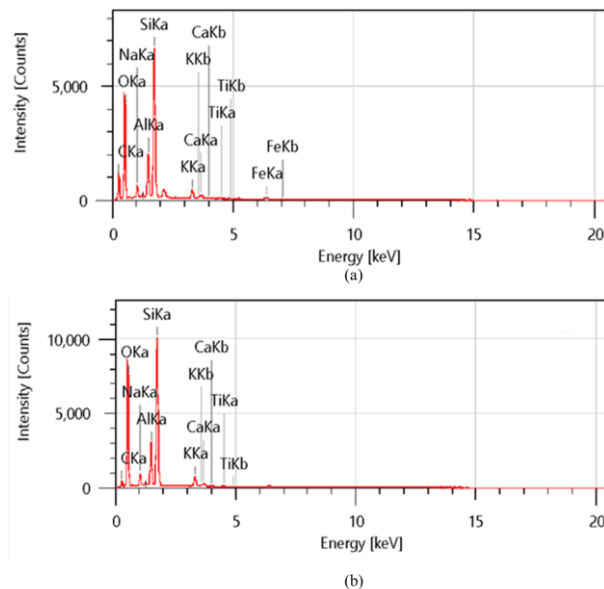

Figure 4. Spectrum of minerals content analysis using EDX on (a) coastal and (b) river sand

The surface morphology of the magnetic material based on coastal sand and river sand was analyzed using Scanning Electron Microscope (SEM). The results of the morphological characterization of coastal sand and river sand are shown in Figure 5. Figure 5(a) shows the morphology of magnetic mineral based on coastal sand and Figure 5(b) shows morphology of magnetic mineral based on river sand. Magnetic mineral based on coastal sand has a relatively uniform particle size compared to magnetic material based on river sand. The particles size of magnetic minerals based on coastal sand is smaller than magnetic material based river sand. Coastal sand has a much finer size compared to river sand.

This is because coastal sand sediments are formed due to the energy of sea waves so that they have a smoother structure. While river sand sediment comes from limestone deposits which have a fine and coarse structure. [33]. River sand sediments also come from fragments of material which generally consist of rock descriptions physically and chemically. These particles range in size from large (boulder) to very fine (colloidal), and various shape from round, oval to square [34]. Sedimentary material will be deposited by the mechanical process of currents originating from rivers and or by ocean currents. Sedimentation in an aquatic environment occurs because there is a high supply of sediment loads in that environment [35].
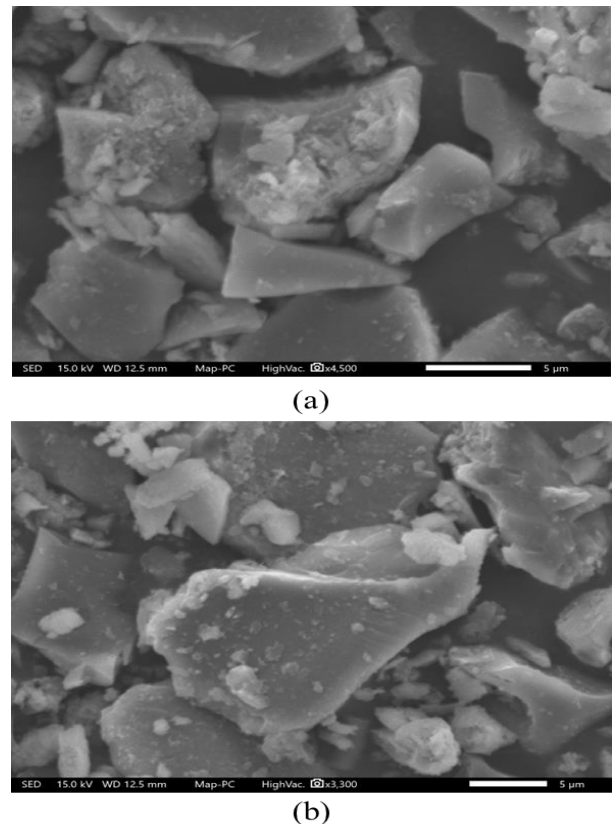

(a)

(b)

Figure 5. Magnetic mineral morphology (a) coastal and (b) river sand analyzed using SEM

Conclusion

The magnetic mineral content of coastal sand is higher than river sand. This proves that the black color possessed by the sand comes from the magnetic mineral contained. Based on AAS analysis, coastal sand has higher Fe content (9.03 mg/gram) than river sand (8.03 mg/gram). This is also confirmed by EDX analysis where the Fe content in coastal sand is 2.07±0.21%. This value is greater than the Fe content of river sand which cannot be measured by EDX. Morphological analysis using SEM shows that coastal sand has a relatively uniform particle size compared to river sand. The particle size of magnetic minerals based on coastal sand is also smaller than that of river sand-based magnetic minerals. Coastal sand has a much finer size compared to river sand. This is caused by coastal sand sediments that are formed due to the energy of sea waves so that they have a smoother structure. While river sand sediments come from limestone deposits that have a fine and coarse structure.

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