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Potential of iron sand from Betaf beach, Sarmi regency and river sand from Doyo, Jayapura regency, Papua as basic materials of mortar as nuclear radiation shielding

E Haryati[1] and K Dahlan[1]

[1]Department of Physics, Faculty of Mathematics and Natural Science, Cenderawasih University, Jayapura 99351, Indonesia

E-mail: [a]endanghfis@gmail.com

Abstract. According to the SNI, the type of concrete for use as nuclear radiation shielding is concrete or mortar that contains hematite, ilmenite, magnetite, barite, or ferrophosphorus synthesis. This study is focused on the characterization of iron sand from and river sand from Papua. The purpose of this research was to determine the specific content of gravity and minerals in iron sand and river sand from Papua. The specific gravities of the sands were measured by manual experiment in a laboratory, while their mineral content were calculated using XRF and SEM - EDS method. The result showed that the specific gravities of iron sand and river sand were 2.66 and 2.50, respectively. The XRF method revealed that the iron sand contained 41.68% Silica, 33.84% Iron, and 24.48% other minerals. The river sand on the other hand contained 58.98% Silica (Si), 26.87% Iron (Fe), and 14.15% other minerals. The SEM -EDS method showed that the iron sand was composed of 39.99 % SiO_2, 21.67 % FeO, and, and 38.34 % others; while the river sand contained 39.28% SiO_2, 17.45 % FeO, and 43.27 % others. The result showed that both sands have the potentials to be isolated from hematite minerals or magnetite.

1. Introduction

Sand is an abundant natural substance in Indonesia. It generally contains silica (Si), Iron (Fe), Aluminium (Al), Magnesium (Mg), and other minerals. The river sand from Bramaputra river of Bangladesh contains iron oxide (21.604%), titanium oxide (2.368%), silicon oxide (39.132%) and other minerals [1], while the heavy fractions of sands along the Brahmaputra River are primarily the source of iron titanium and iron oxide minerals magnetite and ilmenite [2]. The mineral composition of sand in Southern Ontario comprises hornblende, garnet, micas, magnetite, pyroxenes and sphene [3]. Amazon river sand is composed of floodpain sedimen, while Brazilian sand is composed of Silica, Alumunium, Iron, Natrium, Calsium, Kalium, Magnesium and Titanium [4]. Iron sand from the Southern coast of Yogyakarta is composed of magnetite, maghemite, ilmenite and titanomagnetite; whereas its non-magnetic residue mainly consists of silica, alumina and calc [5]. Minerals of sand and rock from Tuban and Sumenep, Tulungagung, Bawean-Gresik Island contain 98.23% CaCO3 in rock samples and 65.9 -76.8% SiO_2 with the highest impurities CaO and Fe2O3 (20- 28%) in sand samples (Tuban and Sumenep) [6]. The quantity of mineral content on every type of sand varies depending on the condition of rocks in the area and sedimentation process.

This research is focused on the analysis of mineral composition in sand substance from two different areas in Papua, Indonesia: Betaf beach in Sarmi regency and Doyo sub-district in Jayapura regency. Sarmi is one of the regencies in Papua that have unlimited amount of natural resources, particularly black sand, also known as iron sand, in its river and coastal areas. In a similar subject, Doyo is a sub-district in Jayapura Regency that also has iron sand resources, although it spreads only on its river zones and the local people mainly use it for buildings constructions.

The widespread use of nuclear technology has put the security factor in its application into serious attention. The technology possesses a certain side effect of radiation that could be completely dangerous for its users. Today, the development of nuclear technology is rapid, especially for medical industry. Despite its benefits, the risk in using nuclear technology must be addressed properly. One of which is through the application of a radiation shield with better quality and reliability in minimizing radiation hazard. The use of nuclear radiation shield is therefore imperative in order to avoid radiation during nuclear technology applications.

According to the SNI 03-2494-2002, the aggregate material for ionizing radiation retaining concrete is a natural material that is accumulated for heavy-weight content that contains hematite minerals (Fe_2O_3), ilmenite ($FeTiO_3$), magnetite (Fe_2O_4), barite ($BaSO_4$), or heavy ferrophosphorus synthetic aggregates (FenP), which is a mixture of iron phosphide [7]. Therefore, in this study we investigated specific gravities and mineral contents of iron sand and river sand as fine aggregate for mortar composition in a nuclear radiation shield [8].

2. Materials and Methods

The iron sand used in this study was obtained from Betaf beach in Sarmi, while the river sand was extracted from a river in Doyo. Both areas are located in Papua, Indonesia. Before the experiment, the iron sand was dried and then purified by using a permanent magnet. The iron sand was put on the magnet to determine the specific gravity value and its mineral content. As for the river sand, it was not treated before the examination.

2.1. Specific Gravity Test

The experiment to determine the specific gravity value was conducted at the Laboratory of Mining and Energy in Papua, by manual experiment method using a pycnometer [9].

2.2. Minerals Content of Iron Sand and River Sand

The examination of mineral contents in both iron sand and river sand was performed by X-ray Fluorescence (XRF) method in the Science Laboratory of FMIPA in the Hassanudin University in Makassar. After that, the samples were sent to the Geological Laboratory of ITB Bandung, for further examination by Scanning Electron Microscopy with Dispersive Spectrometer (SEM - EDS) method.

3. Result and Discussions

3.1. Specific Gravity Value

The specific gravity values for the iron sand from Sarmi and the river sand that was obtained from Doyo, in Jayapura are presented in Table 1.

Table 1. Specific gravity values of iron sand from Sarmi and river sand from Doyo Jayapura.

No	Material	Specific Gravity
1	River sand	2.50
2	Iron sand	2.66

Table 1 shows that the specific gravity value of iron sand is greater than the river sand. This result revealed that the iron sand has a smaller volume than river sand. The Indonesian National Standard (SNI 03-1970-1990) on specific gravity values assumes that the specific aggregate gravity rate ranges from 2.5 to 2.7 [10]. Therefore, from this result we can see that the two aggregates have met the minimum established standard and they can be applied as materials in mortar composition.

3.2. Mineral Contents of iron sand and river sand
3.2.1. XRF Method

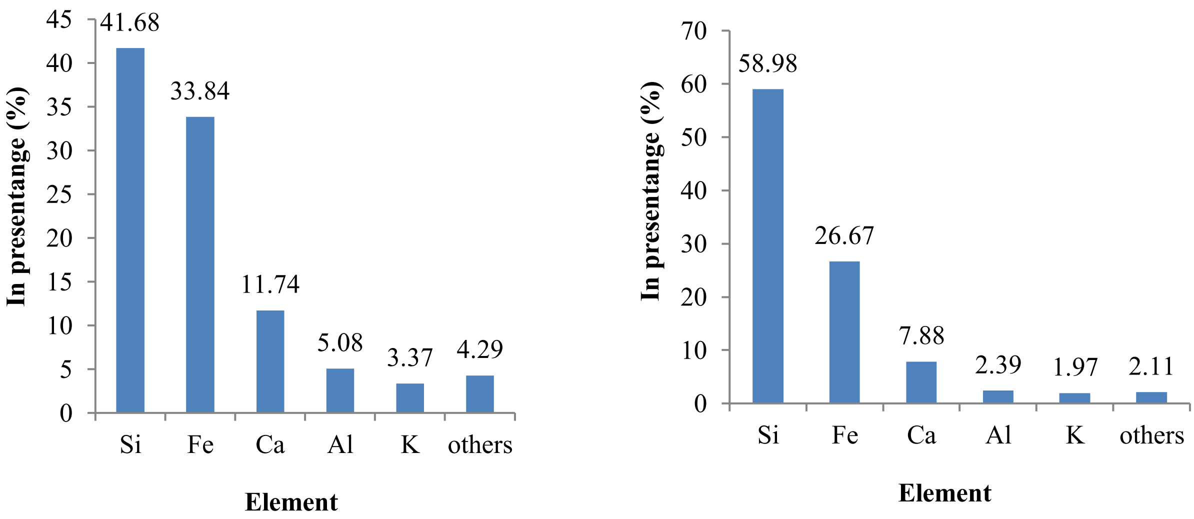
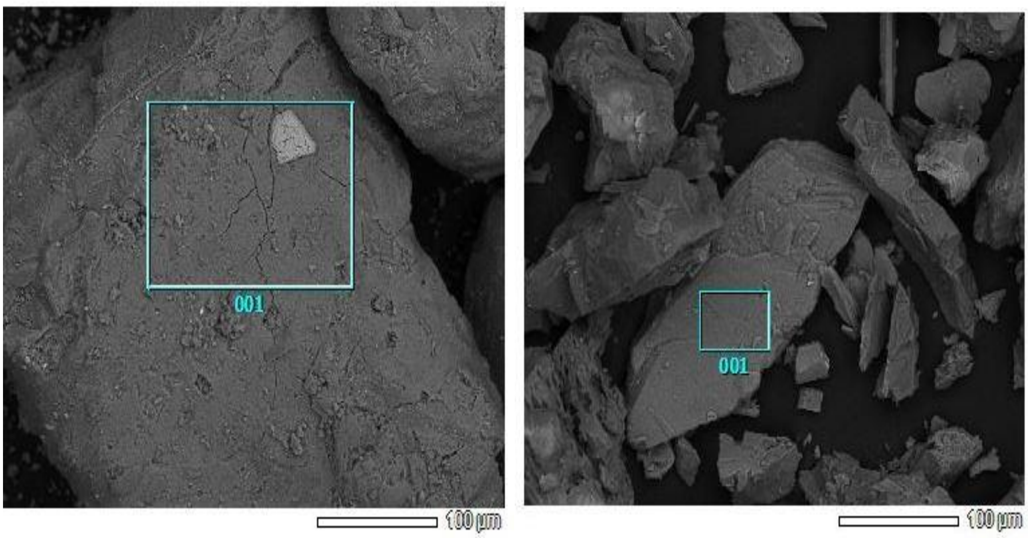


Figure 1. Mineral contents of (a) iron sand and (b) river sand.

Figures 1 displays that mineral contents in both sands are dominated by Silica (Si) and Iron (Fe). The iron sand contains 41.68% Si and 33.84% Fe, in contrast to the river sand that contains 58.98% Si and 26.67% Fe. The iron sand contains more iron than the river sand. However, the silica content of the river sand is much higher than the iron sand. The mineral compositions of both samples were influenced by the sand formation process and the site where the samples were obtained.

3.2.2. SEM-EDS Method



(a) (b)

Figure 2. SEM image of (a) River Sand and (b) Iron sand.

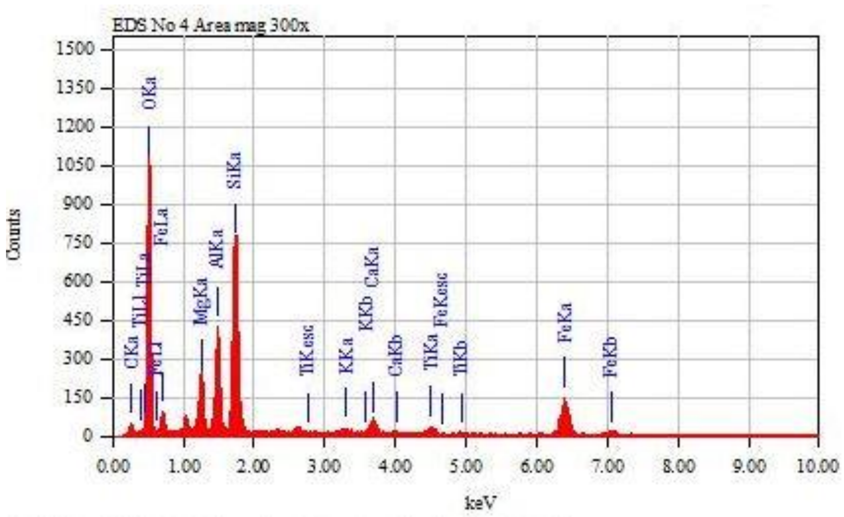


Figure 3. Grafik EDS river sand.

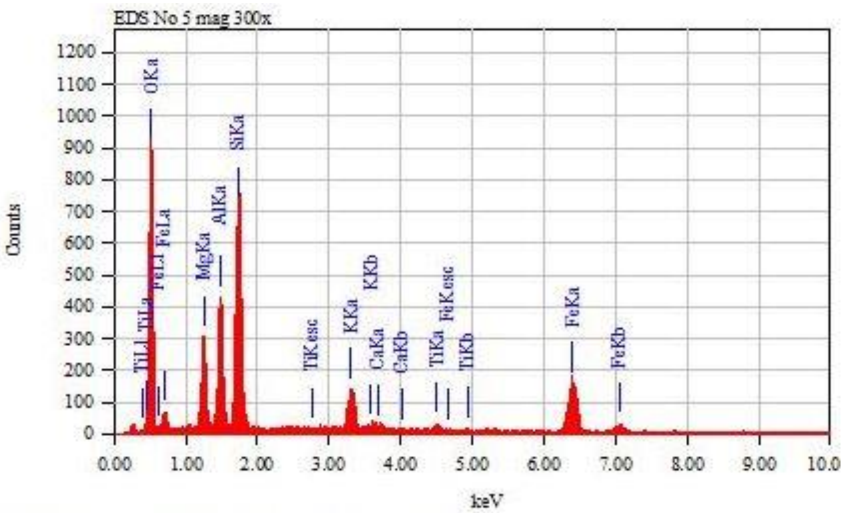


Figure 4. EDS spectra of iron sand.

From Figure 3 and 4, we can see that the highest peak for the iron sand and the river sand is the maximum value of Silica (Si), followed by the apex of iron (Fe), while the remaining numbers represent other minerals contained in the samples.

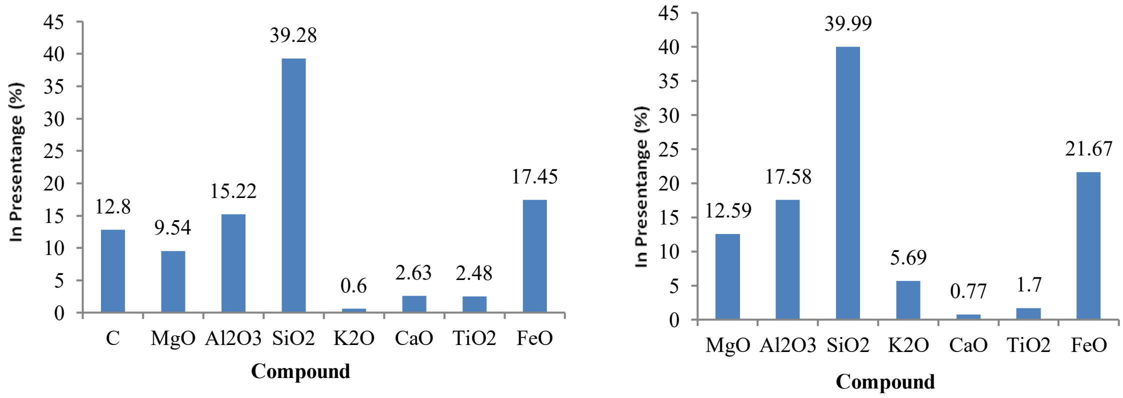


Figure 5. Mineral compounds of iron sand (a) and river sand (b).

Figures 5 show that SiO2 and FeO are the main contents in both samples. However, in the iron sand, the FeO content is greater compared to the river sand. From the results of XRF and SEM-EDS testings, we have revealed that both sands contain large quantities of iron (Fe).

4. Conclusions

The Iron sand from Betaf beach in Sarmi Regency and the river sand from Doyo, Jayapura Regency have been characterized by XRF and SEM-EDS method. Both of sands contain large quantities of Iron (Fe), it is therefore possible to isolate hematite minerals (Fe_2O_3), limeite ($FeTiO_3$), or magnetite (Fe_2O4) from iron sand and river sand [11]. Thus we can conclude that these materials can be used in a nuclear radiation shield, when it is applied into composition for concrete and mortar.

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