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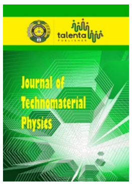

Manufacture and Characterization of Porous Ceramics Based On Clay Soil And Banana Frond Powder

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Abstract. This work reports the manufacture and characterization of porous ceramics synthesized using clay and banana frond powder by employing the dry-pressing method. The clay and banana frond powder was filtered with a grain size of 200 mesh. Production of printed ceramics was made with the proportion of the combination of clay and banana frond powder of 100%:0%; 95%:5%; 90%:10%; 85%:15%; 80%:20%; 75%:25%; 70%:30%; 65%:35%; 60%:40%; 55%:45%; 50%:50% and heated with a sintering temperature of 1000°C with a holding time of 3 hours. The resulting ceramics are described by determining their actual properties (thickness, porosity, and shrinkage), mechanical properties (compressive strength and hardness), surface morphology and pore size (SEM), and base material (EDX). The results show that the mixed varieties of 50%:50% clay and banana frond powder have a density value of 1.22 g/cm^3, a porosity of 41.31%, and heat loss of 11.41 %, compressive strength of 1.36 MPa, and hardness of 99.15 MPa. The surface morphology results showed that the sample has evenly distributed pore sizes of 10.54 m, 10.77 m, and 12.15 m, which is called a macroporous ceramic with a pore size of > 50 nm.

Keywords: Banana Frond Powder, Clay, Macroporous Ceramic, Porous Ceramics, SEM.

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1. Introduction

The manufacture of porous ceramics using clay and mud soils attracts researchers' attention nowadays[1]. In addition, research on the manufacture of sludge-based porous ceramics with porous and porosity tests based on variations in soil structure and sludge and sawdust has also been carried out, with the number of pore-making materials being variables that determine the penetrating power and porosity of ceramics [2].

The waste from plants, such as rice husks, bagasse, and sawdust, can be used as a combination of ceramic and clay soil as the basic material [3]. One of the selected natural ingredients that can be used is banana frond powder. The properties of sludge that shrink when consumed at high

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temperatures cause changes in the mass and the burned aspects. For example, research [4] shows that alumina pottery experienced layered shrinkage of up to 11.3% at an ignition temperature of 1650 ^oC. In addition, soil minerals are usually connected with humus, a natural compound in the soil.

Clay soils are formed over silica rocks through carbonic corrosive, corrosive processes and are somewhat made from geothermal action. The earth forms hard knots when dry and is sticky when wet with water. It is not set when the upper rock of the earth's mineral type controls it. Sludge minerals are grouped by the action of layers of silicon oxide as well as aluminum oxides that make up their precious stones [5]. Secondary clay or sediment is a type of soil that arises due to the deposition of feldspathic rocks that move far from the parent rock due to exogenous forces, as well as on the way mixed with natural and inorganic materials to change the synthetic and actual properties of the sludge. How much extra sludge is more than essential loamy soil [6].

Most of the fronds of bananas were ignored after the tree was shown to bear fruit. The potential for wasting banana stems is very large in agricultural areas, especially in Indonesia. Banana products can be found in almost all sub-regions; even the number of banana plants in 2005 reached about 800,000 trees, with an estimated creation of 80%. So it is estimated that 640,000 banana sticks are wasted [7]. Banana fronds are pieces of the stem that start from the root to the base of the banana leaf in the middle that extends and gathers on the other side to form a stem-like design [8]. The lignin content in banana fronds is 12.25%, while the fiber is rather long, around 4.29 mm. The low lignin content in the fronds provides an economic advantage. In addition, banana fronds have a specific gravity of 0.29 g/cm^3 with a fiber length of 4.20 – 5.46 mm [9].

Based on the above explanation, this work reports the manufacture and characterization of porous ceramics synthesized using clay and banana frond powder by employing the dry-pressing method.

2. Methodology

All materials, such as banana frond powder and clay, were prepared. The variations in soil and banana frond powder composition were 100%:0%; 95:5%, 90:10%, 85:15%, 80:20%, 75:25%, 70:30%, 65:35%, 60:40%, 55:45%, 50:50% with the addition of 10 drops of aquades. First, the mixture was stirred to a homogeneous for 5 minutes using a mortar and mump with a weighing material of 10 grams. After that, the homogeneous mixture was poured into a mold sized 3 x 3 x 1 cm. Then, it was pressed with a pressure of 5 tons and held for 10 minutes, followed by cooling down to remain at room temperature and drying for five days to remove the moisture content. The sample was then sintered at a sintering temperature of 1000 ^oC with a holding time of 3 hours. Then, the sample was cooled down for 24 hours in the combustion furnace. The characterization includes physical properties (density, porosity, and burn shrinkage), mechanical properties (compressive strength and hardness), morphological Tests, and element content with SEM-EDX.

3. Result and Discussion

3.1 Density Testing

Density testing is completed by estimating the sample's mass and the sample's volume that has been sintered after measurements have been made to obtain the results of the density test of porous ceramics.

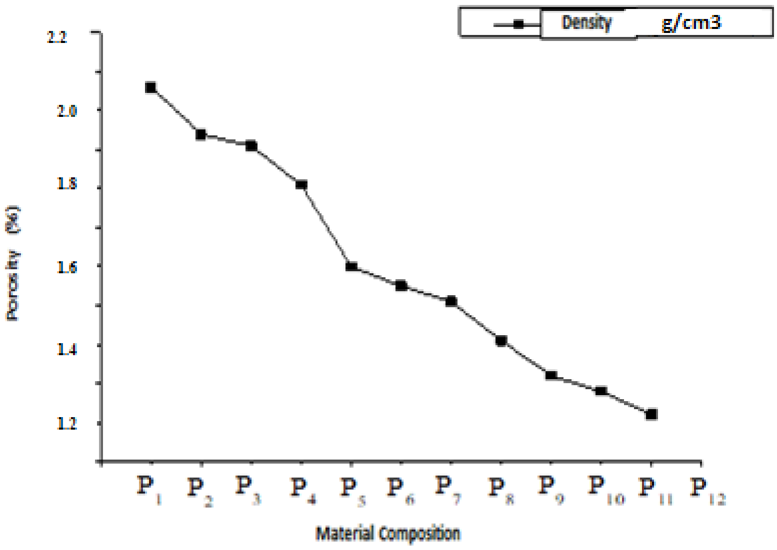

Figure 1. Material Density Testing

Figure 1 shows that the density value obtained in the test results has decreased; this decrease is due to the high oxygen element (O) contained in banana frond powder during the combustion process causing pore traces in ceramics.

This condition affects the mass value and volume in the sample; the more banana frond powder is added to the clay soil in ceramics, the more the mass value in ceramics decreases but is inversely proportional to the volume value the more the mixture of banana frond powder to clay soil (clay) then the pore traces caused more and more to make the volume of ceramics increase.

3.2 Porosity Testing

The porosity test of porous ceramic production was completed by estimating the dry mass as well as the volume of the sample after consumption and the wet weight of the sample after watering for 24 hours and allowed to represent 1 hour after being taken out of the soaking. The condition of the test was based on ASTM C 20-92 to calculate the porosity of the material [10].

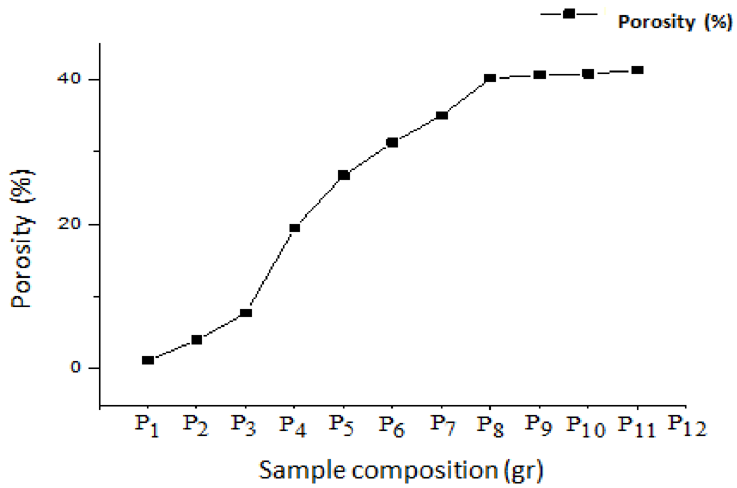

Figure 2. Results of material porosity testing

Figure 2 shows that the porosity value obtained in this test is increasing due to the large addition of banana frond powder to clay soil, and more pores are produced in ceramics.

3.3 Heating Shrinkage Testing

The porous ceramic heat shrinkage test is completed by estimating the volume of the sling before burning and the volume of the sample after sintering.

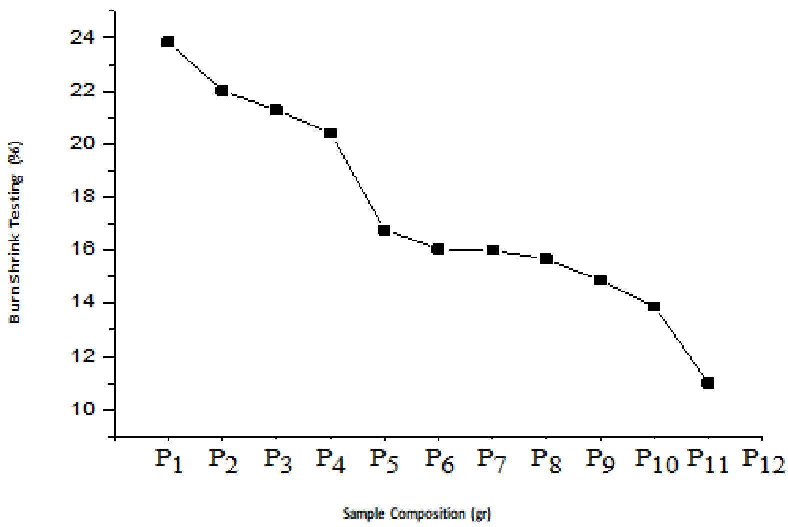

Figure 3. Graph of Heating Shrinkage Test

This is because the mass and volume of ceramics do not shrink largely without adding banana frond powder, so the ceramics shrink a lot. In contrast, adding 50% banana frond powder and 50% clay soil ceramics reduced mass, and the volume increased due to pores caused during combustion, causing the sample to shrink slightly.

3.4 Compressive Strength Testing

The compressive strength test of porous ceramic production is completed by estimating the greatest compressive strength that can be withstood over combustion and surface area.

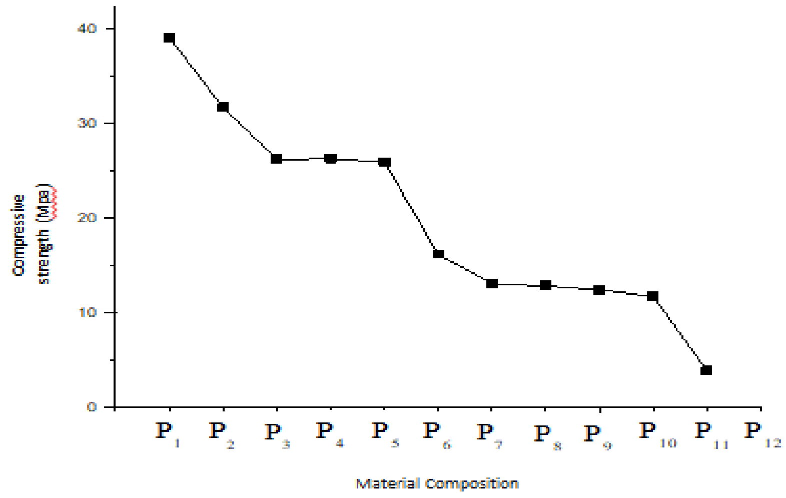

Figure 4. Compressive strength test results

Figure 4 shows that the compressive strength of the ceramics is reduced. This decrease is due to the pores in ceramics causing the ceramics to become light and brittle, and the compressive strength value also decreases.

This can be seen in the sample of 10% clay soil has a compressive strength value of 39.12 MPa this sample, without the addition of banana frond powder, the sample is denser and has smaller pores, so that the sample is stronger and produces a higher compressive strength price than 50% clay soil and 50% banana frond powder has a compressive strength value of 3.85 MPa due to the addition of banana frond powder the sample has a larger pore so that the sample has a low compressive strength value.

3.5 Hardness Testing

The porous ceramics hardness test was completed by estimating the hardness at three combustion marks the length of the flat inclined plane (a) and the length of the upward slope (b). Then, at that point, a long inclined sling was determined (d) using a specific load on each of the slings, with a time of 30 seconds and then determining at the microstructure, then, at that time, the results of the estimated hardness at the three points were taken the normal values.

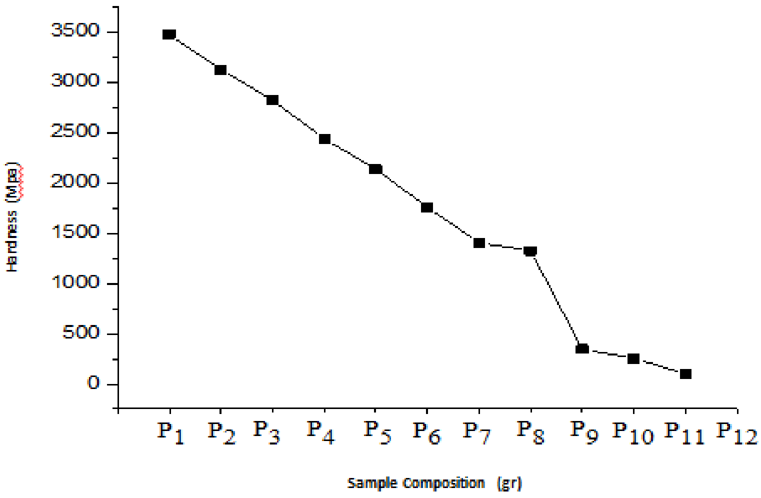

Figure 5. Material hardness testing results

Figure 5 shows that the hardness value has decreased; this decrease is directly proportional to the compressive strength value due to the pores in the ceramics caused during combustion. For example, a 10% sample without adding banana frond powder has a hardness value of 3,472.451 MPa because the sample has a small pore which causes the sample to be denser. The hardness value is high in contrast to the sample addition of 50% banana frond powder and 50% clay soil, which has a hardness value of 99.15 MPa because the pores in the sample cause the hardness value to be lower.

3.6 Morphological Testing

The surface morphology was depicted using a scanning electron microscope – Energy Dispersive X-Ray (SEM-EDX). The sample taken is approximately 5 grams from each sample.

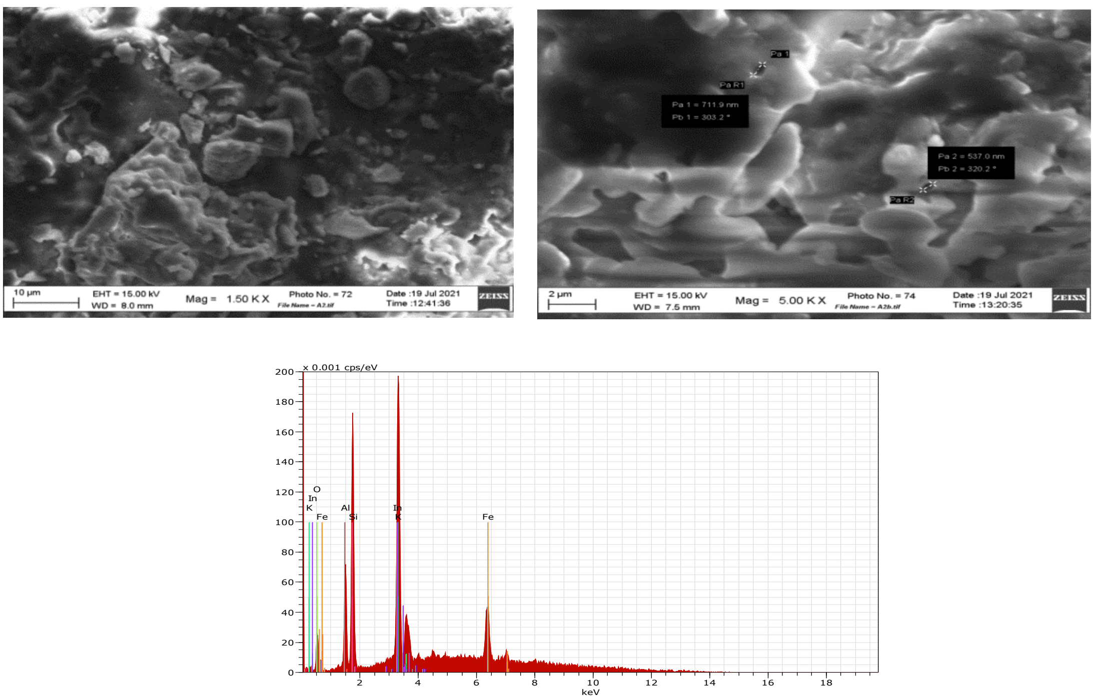

Figure 6. SEM Results of the Sample of a Mixture of 10%:0% At 500 Times Magnification

Table 1. The Result of the EDX Component of The Sample With a Mixture of 10%:0% at 500 Times Magnification

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]	K fact.	Z corr.	A corr.	F corr.
Fe	26	K-series	11.31	34.09	24.55	0.44	0.114	2.881	1.000	1.036
K	19	K-series	7.88	23.74	24.42	0.29	0.061	3.818	1.000	1.022
In	49	L-series	5.47	16.48	5.77	0.23	0.065	2.485	1.000	1.014
Si	14	K-series	4.53	13.64	19.53	0.23	0.044	3.087	1.000	1.010
O	8	K-series	2.52	7.59	19.07	0.75	0.055	1.383	1.000	1.000
Al	13	K-series	1.48	4.47	6.66	0.11	0.016	2.768	1.000	1.010
		Total:	33.19	100.00	100.00					

From the readings of the EDX components (Figure 6 and Table 1), it tends to be seen that six components are distinguished in a combination of 10% clay soil without the addition of banana frond powder, elements Fe, K, Si, O components contained when sintered ceramics can be found on clay soils.

However, there is an addition of In and Al elements due to the combustion process, so there is an addition of elements to ceramics. The most Fe element comes from its bond with the O that makes up Fe_3O_2 in ceramics.

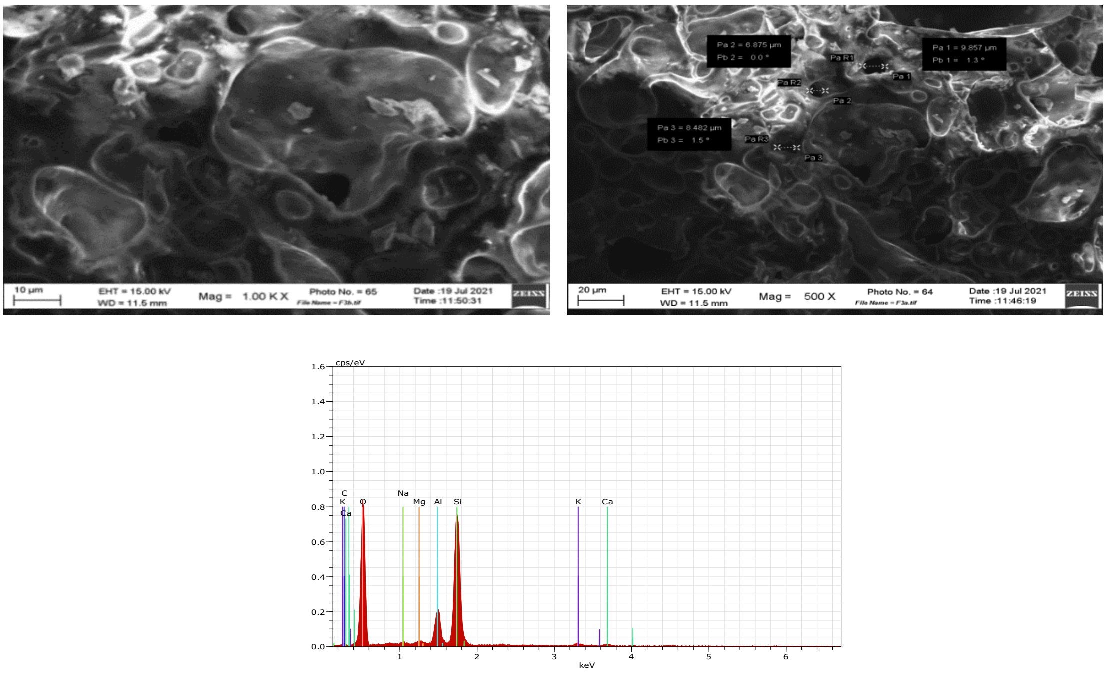

Figure 7. SEM Results of the Sample of a Mixture of 75%:25%At 500 Times Magnification

Table 2. The Result of the EDX Component of The Sample With a Mixture of 75%:25% at 500 Times Magnification

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]	K fact.	Z corr.	A corr.	F corr.
O	8	K-series	45.60	51.40	64.93	6.15	0.654	0.786	1.000	1.000
Si	14	K-series	33.66	37.94	27.31	1.44	0.265	1.430	1.000	1.002
Al	13	K-series	6.06	6.83	5.11	0.33	0.041	1.641	1.000	1.018
K	19	K-series	1.21	1.37	0.71	0.11	0.007	2.016	1.000	1.014
Ca	20	K-series	1.15	1.30	0.66	0.11	0.007	1.787	1.000	1.015
Mg	12	K-series	0.39	0.44	0.36	0.06	0.003	1.544	1.000	1.012
Na	11	K-series	0.33	0.37	0.33	0.06	0.003	1.351	1.000	1.006
C	6	K-series	0.31	0.36	0.60	0.28	0.007	0.510	1.000	1.000
		Total:	88.72	100.00	100.00					

The results of EDX (Figure 7 and Table 2) show that the eight components that are distinguished in the sample combination of 75% clay soil (clay) and 25% banana frond powder, Components O, Si, Al, K Seen as in sintered ceramics can be found on clay soils (clay). However, the addition of elements Ca, Mg, Na, and C to ceramics is due to the bond between the two materials at the time of combustion, causing the addition of elements to ceramics. The presence of the O component generally comes from its bond with the Si that makes up the SiO_2 in ceramics, then the O element that causes pores in ceramics.

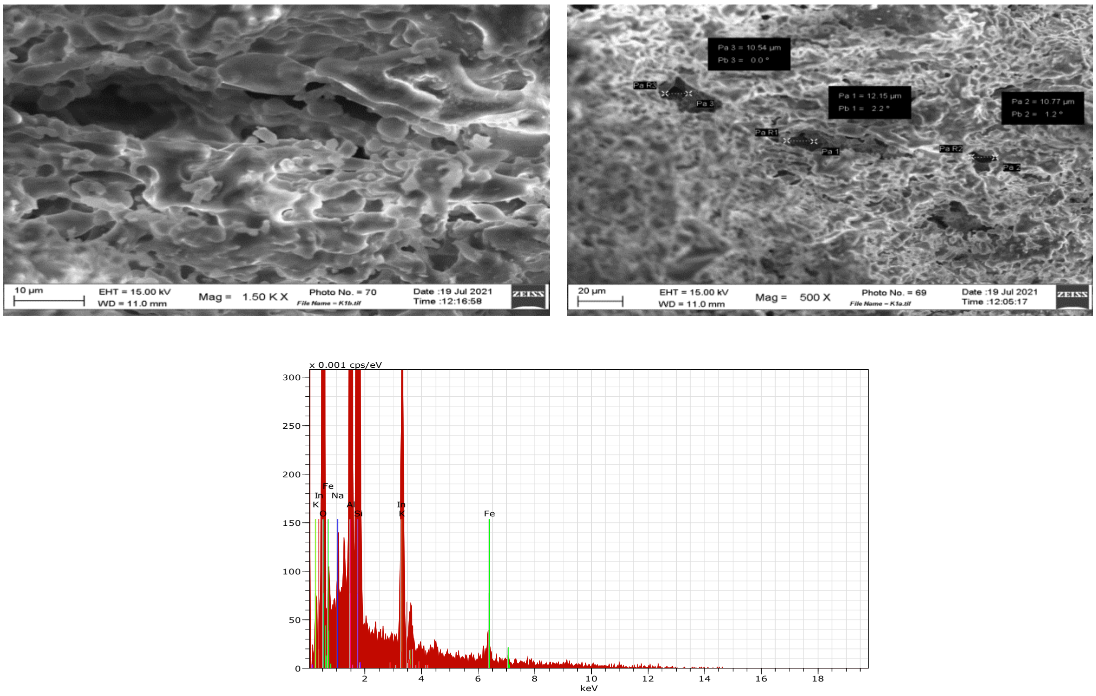

Figure 8. SEM Results of the Sample of a Mixture of 50%:50% at 500 Times Magnification

Table 3. The Result of the EDX Component of The Sample With a Mixture of 50%:50% at 500 Times Magnification

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]	K fact.	Z corr.	A corr.	F corr.
O	8	K-series	70.58	57.05	71.68	9.61	1.084	0.526	1.000	1.000
Si	14	K-series	29.67	23.98	17.16	1.30	0.200	1.195	1.000	1.004
Al	13	K-series	12.47	10.08	7.51	0.64	0.093	1.065	1.000	1.013
K	19	K-series	4.47	3.61	1.86	0.22	0.023	1.521	1.000	1.014
In	49	L-series	3.60	2.91	0.51	0.21	0.029	0.990	1.000	1.011
Fe	26	K-series	1.92	1.55	0.56	0.19	0.012	1.191	1.000	1.071
Na	11	K-series	1.02	0.83	0.72	0.13	0.010	0.847	1.000	1.005
		Total:	123.73	100.00	100.00					

The SEM-EDX results (Figure 8 and Table 3) show that seven components identified in the sample combination of 50% clay soil (clay) and 50% banana frond powder, components O, Si, Al, and K contained when ceramics that have been sintered are indeed found in clay soils. However, adding In, Fe and Na elements to ceramics caused by the bond between the two materials at the combustion time caused the addition of elements to ceramics. The presence of the O component comes mostly from its bond with the Si that makes up the SiO_2 in ceramics, hence the O element that causes pores in ceramics.

5. Conclusion

In summary, this work proved that banana frond's clay and frond powder could be used as natural materials to manufacture porous ceramics. The ceramic test with the development of banana frond powder of 50% composition has the highest characteristic value of porosity, 41.31%, and hardness, 2,133.137 MPa. SEM-EDX results, in samples with a composition variation of 10:0%, have a pore size of 537.0 nm and 711.9 nm; in samples with a mixture of variations of 75:25% have a pore size of 6.875 μm, 8.482 μm, and 9.857 μm, in samples with a mixture of variations of 50:50% have a pore size of 10.54 μm, 10.77 μm, and 12.15 μm. The effect of adding banana frond powder in manufacturing porous ceramics made from clay soil (clay) on pore size shows a larger pore size than without adding banana frond powder. In addition, it increases its porosity value which ranges from 1.20 – 41.31%. The combined variety of clay soil (clay) and banana frond powder strongly affects subsequent porous ceramics. Tests that have been carried out show that the real properties of porous ceramics include: a thickness of 2.06 – 1.22 g/cm^3 (decreased), porosity a value of 1.20 – 41.31% (experienced in absorption), and burn shrinkage a value of 20.41 – 11.01% (decreased), and in mechanical properties, namely compressive strength of 39.121 – 3,858 MPa (decreased) and hardness of 2,133.137 – 99.15 MPa (decreased).

REFERENCES

[1] K. K. D. Sengphet, K. Pasomsouk, T. Sato, M. N. A. Fauzi, O. Radzali, "Fabrication of Porous Clay Ceramics Using Kenaf Powder Waste," *International Journal of Scientific and Research Publications.* vol. 3, no. 8, 2013.

[2] I. Yakub, A. Plappally, M. Leftwich, K. Malatesta, "Porosity, Flow, And Filtration Characteristics Of Frustum-Shaped Ceramic Water Filters," *Journal of Environmental Engineering,* vol. 139, no. 7, 2013.

[3] Sukarma R. Buku Panduan Pembuatan Filter Keramik: Yayasan Tirta Indonesia Mandiri. 2011.

[4] B. B. Rana, A. Sultan, F. A. M. Shaheen, F. Salman, W. A. Shah, "Forming of Alumina Ceramics," *Journal Chemical Society Pakistan,* vol. 31, no. 2, 2009.

[5] K. Terzaghi and R. B. Peck, Mekanika Tanah Dalam Praktek Rekayasa Edisi Kedua, Jakarta: Erlangga, 1987.

[6] Sugihartono, Wawasan tentang keramik: Mengenal Lempung/Tanah Liat sebagai Bahan Pokok untuk Produk Keramik. 2000.

[7] S. Y. Prabawati and A. G. Wijaya, "Pemanfaatan Sekam Padi dan Pelepah Pohon Pisang Sebagai Bahan Alternatif Pembuat Kertas Berkualitas," *Jurnal Aplikasi Ilmu – Ilmu Agama,* vol. IX, no. 1, 2008.

[8] R. Bhoopathi, M. Ramesh, and C. Deepa, "Fabrication and Property Evaluation of Banana-Hemp-Glass Fiber Reinforced Composites," *Procedia Engineering,* vol. 97, pp. 2032-2041, 2014.

[9] Munadjim, Teknologi Pengolahan Pisang Edisi Ketiga, Jakarta: Gramedia, 1988.

[10] D. R. Sihite, "Pembuatan Dan Karakterisasi Bahan Keramik Berpori Dengan Aditif Sekam Padi Yang Digunakan Sebagai Filter Gas Buang," M.S. Thesis, Universitas Sumatera Utara, Medan, 2008.