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Identification of Rare Earth Metal Content in Fly Ash and Bottom Ash Coal Combustion of PT Bosowa Energi PLTU Jeneponto Regency

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ABSTRACT

Rare Earth Metals are the formation of fifteen elements and two other elements, namely scandium (Sc) and yttrium (y). Rare earth metals are known for their presence in coal minerals and coal ash residue from coal combustion at PLTU PT Bosowa Energi. This study aims to determine the rare earth elements in Fly Ash and Bottom Ash. The method stages of this research are sampling at the power plant, sample preparation, and sample testing using the ICP-OES method. Based on the results of the ICP-OES test, six rare earth elements were detected in the fly ash. Bottom ash samples, namely Lanthanum (La), Gadolinium (Gd), Neodymium (Nd), Serium (Ce), Samarium (Sm), and Terbium (Tb). The dominant concentrations of these rare earth metals are La and Ce, while the lowest concentration is Tb. The conclusion of this study is that the content of rare earth elements in fly ash is Lanthanum (La) = 34.20 ppm to 65.10 ppm; Gadolinium (Gd) = 7.30 ppm to 8.10 ppm; Neodymium (Nd) = 7.90 ppm to 27.60 ppm; Serium (Ce) = 30.10 ppm to 96.60 ppm; Samarium (Sm) = 4.50 ppm to 8.00 ppm; Terbium (Tb) = 1.10 ppm to 1.30 ppm. The content of rare earth elements in bottom ash is Lanthanum (La) = 33.50 ppm to 38.10 ppm; Gadolinium (Gd) = 4.80 ppm to 5.90 ppm; Neodymium (Nd) = 7.90 ppm to 27.60 ppm; Serium (Ce) = 10.90 ppm to 11.00 ppm; Samarium (Sm) of 6.40 ppm to 7.00 ppm; Terbium (Tb) = 1.20 ppm to 1.40 ppm.

Keywords: PLTU, Rare Earth Elements, Fly Ash, Bottom Ash, ICP-OES.

1. INTRODUCTION

Coal is a sedimentary rock consisting of organic matter, several organic rock fragments, and mineral materials, such as clay, shale, quartz, and calcite [1].

The utilization of coal in PLTU serves as fuel for boilers. The boiler will generate steam and drive a turbine connected to a generator to generate electricity. In the coal combustion process, it will produce residual combustion in the form of coal ash in the form of fly ash, and bottom ash [2].

The problem at the research site is that most of the material from coal combustion has yet to be utilized and is suspected of containing other valuable elements, such as rare earth metals. Rare earth metals are known to be present in coal and coal ash. In coal, rare earth metals are present in minerals and ash from coal combustion at PLTU [3].

Rare earth metals are a group of chemical elements that are all composed of metals. Rare earth metals are formed from fifteen elements and two other elements, namely scandium (Sc) and yttrium (y) [4].

The first research uses coal ash waste as a source of rare earth metals. The results of this study showed that the serium content was between 22.2 ppm - 84.8 ppm in fly ash, while in bottom ash, the serium content was 17.1 - 64.2 [5]. Analysis of instrumental neutron activation of steam power plants in eastern Indonesia, the element of cerium in fly ash is 4.5 mg/Kg, while in bottom ash, it is 6.1 mg/Kg [6]. A power plant in Japan contained 420 mg/Kg of total rare earth metals in fly ash [7], US Kentucky PLTU has rare earth metals between 1,213,6-1,667.6 mg/Kg [8],

Furthermore, other research carried out is the analysis of the potential for rare earth metals, coal ash from the mine mouth PLTU PT Wanatiara Persada Kawasi Obi waste [9],

This research has not carried out at the PLTU PT Bosowa Energi Jeneponto Regency. Therefore, the author was compelled to take this title to identify the content of rare earth metals in fly ash and bottom ash. This study aimed to determine the content of rare earth metals in fly ash and bottom ash.

2. METHODOLOGY

The method used to identify the content of rare earth metals in fly ash and bottom ash uses the ICP-OES (Inductively Coupled Plasma-Optical Emission Spectrometry) variant of Perkin Polymer Optima 8300. The test was carried out at the Nuclear Minerals Technology Laboratory-BATAN. Before the analysis, the sample was prepared first. Preparation begins by sampling fly ash and bottom ash so that the samples to be tested are representative. Next, sampling was done by qoning and quartering methods. The qoning and quartering methods were carried out by making mounds of fly ash and bottom ash, then leveling them and dividing them into four parts, and then taking the diagonals. Then the fly ash and bottom ash are destroyed to form a solution to dissolve the elements present in the fly ash and bottom ash so that they can be analyzed using ICP-OES.

3. RESULT AND DISCUSSION

A. Rare earth metal analysis results

The results of the analysis of rare earth metals in fly ash and bottom ash using the ICP-OES (Inductively Coupled Plasma-Optical Emission Spectrometry) method in detail can see in table 1.

Table 1. The results of the analysis of rare earth metals in fly ash and bottom ash

NO	Rare Earth Elements	Concentration (ppm)			
		Fly Ash 1	*Fly Ash* 2	*Bottom Ash* 1	*Bottom Ash* 2
1	Lanthanum (La)	34.20	65.10	38.10	33.50
2	Gadolinium (Gd)	7.30	8.10	5.90	4.80
3	Neodymium (Nd)	7.90	27.60	10.90	11.00
4	Cerium (Ce)	30.10	96.60	38.00	32.50
5	Samarium (Sm)	4.50	8.00	6.40	7.00
6	Terbium (Tb)	1.10	1.30	1.40	1.20
7	Yttrium (Y)	<IDL 0.13	<IDL 0.13	<IDL 0.13	<IDL 0.13
8	Praseodymium (Pr)	<IDL 0.10	<IDL 0.10	<IDL 0.10	<IDL 0.10
9	Europium (Eu)	<IDL 0.12	<IDL 0.12	<IDL 0.12	<IDL 0.12
10	Dysprosium (Dy)	<IDL 0.10	<IDL 0.10	<IDL 0.10	<IDL 0.10
11	Holmium (Ho)	<IDL 0.10	<IDL 0.10	<IDL 0.10	<IDL 0.10
12	Thulium (Tm)	<IDL 0.10	<IDL 0.10	<IDL 0.10	<IDL 0.10
13	Ytterbium (Yb)	<IDL 0.14	<IDL 0.14	<IDL 0.14	<IDL 0.14
14	Lutetium (Lu)	<IDL 0.11	<IDL 0.11	<IDL 0.11	<IDL 0.11
15	Scandium (Sc)	<IDL 0.13	<IDL 0.13	<IDL 0.13	<IDL 0.13

The table above shows that six elements of rare earth metals identified in all samples, namely fly ash 1, fly ash 2, bottom ash 1, and bottom ash two from the coal combustion residue of PT Bosowa Energi PLTU. The identified rare earth elements include Lanthanum (La), Gadolinium (Gd), Neodymium (Nd), Cerium (Ce), Samarium (Sm), and Terbium (Tb). In contrast, elements that are not detected contain rare earth metals, including Yttrium (Y). , Praseodymium (Pr), Europium (Eu), Dysprosium (Dy), Holmium (Ho), Tulium (Tm), Ytterbium (Yb), Lutetium (Lu) and Scandium (Sc). Elements whose rare earth metal content is not seen are due to their relatively lower concentrations than the Instrument Detection Limit (IDL). Based on the table above, the test results on fly ash and bottom ash are known that the elements that have the most dominant concentrations of rare earth metals are Lanthanum (La) and Serium (Ce). Meanwhile, the rare earth metal with the lowest concentration in fly ash and bottom ash is Terbium (Tb).

The presence of rare earth elements in fly ash and bottom ash from PLTU combustion is influenced by the coal used [10]. PLTU PT Bosowa Energi Jeneponto Regency uses coal from South Kalimantan and East Kalimantan with three coal supplying companies, namely PT Adaro Indonesia, PT Satya Mitra Surya Perkasa dan PT Kideco Jaya Agung.

The coal combustion process of PT Bosowa Energi PLTU at a temperature range of 1200°C to 1400°C. The type of coal combustion used in the PLTU PT Bosowa Energi is currently pulverized coal burning (Pulverized Mill). Where the coal is first pulverized through a pulverized mill until it becomes powder (as fine as flour) then it is channeled to the boiler for the combustion process.

a) *Fly Ash* 1

The ICP-OES analysis on fly ash 1 showed that the highest concentration of rare earth metals was Lanthanum (La), with a concentration of 34.20 ppm. Serium (Ce) with the second highest concentration after lanthanum, which is 30.10 ppm. Neodymium (Nd) is a rare earth metal with the third largest concentration, 7.90 ppm. Gadolinium (Gd) is a rare earth metal with the fourth largest concentration, 7.30 ppm. Samarium (Sm) with a concentration of 4.50 ppm. The lowest concentration of rare earth metals was Terbium, with a concentration of 1.10 ppm. Variations in the concentration of rare earth metals in fly ash 1 can be seen in Figure 1

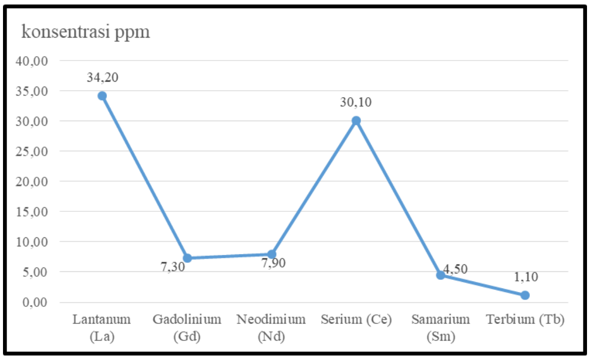

Figure 1. Variation of rare earth metal concentration in fly ash 1

b) *Fly Ash* 2

Fly ash 2, it shows rare earth metals from the ICP-OES analysis with the highest concentration detected in the element Serium (Ce) with a concentration of 96.60 ppm. Lanthanum (La) is the second-highest rare earth metal seen with a concentration of 65.10 ppm. Neodymium (Nd) is the third-highest rare earth metal, with a concentration of 27.60 ppm. Gadolinium (Gd) with a concentration of 8.10 ppm and samarium (Sm) with a concentration of 8.00 ppm. While the rare earth metal with the lowest concentration is Terbium (Tb), with a concentration of 1.30 ppm. Variations in the concentration of rare earth metals in fly ash 2 can be seen in Figure 2

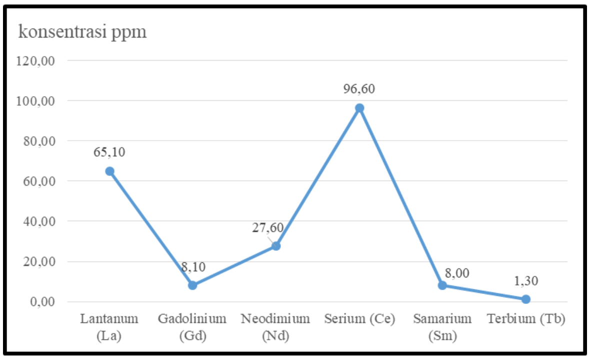

Figure 2. Variation of rare earth metal concentration in fly ash 2

c) *Bottom Ash* 1

The rare earth metal detected with the highest concentration in bottom ash 1 was Lanthanum (La), with a concentration of 38.10 ppm. Furthermore, the second rare earth metal with the highest concentration is Serium (Ce), with a concentration of 38.00 ppm. Neodymium (Nd) is the third rare earth metal with a concentration of 10.90 ppm. Samarium (Sm) is the fourth rare earth metal with a concentration of 6.40 ppm, and Gadolinium with a concentration of 5.90 ppm. Rare earth metals the lowest concentration is Terbium (Tb), with a concentration of 1.40 ppm. Variations in the concentration of rare earth metals in bottom ash

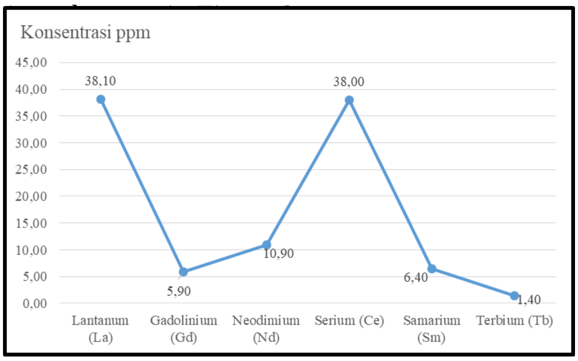

Figure 3. Variation of rare earth metal concentration in bottom ash 1

d) *Bottom Ash* 2

The rare earth metal detected with the highest concentration in bottom ash 2 was Lanthanum (La), with a concentration of 33.50 ppm. Furthermore, the second rare earth metal with the highest concentration was Serium (Ce), with a concentration of 32.50 ppm. Neodymium (Nd) is the third rare earth metal with a concentration of 11.00 ppm. Samarium (Sm) is the fourth rare earth metal with a concentration of 7.00 ppm, and Gadolinium with a concentration of 4.80 ppm. Rare earth metals the lowest concentration is Terbium (Tb), with a concentration of 1.20 ppm. Variations in the concentration of rare earth metals in bottom ash 2 can be seen in Figure 4

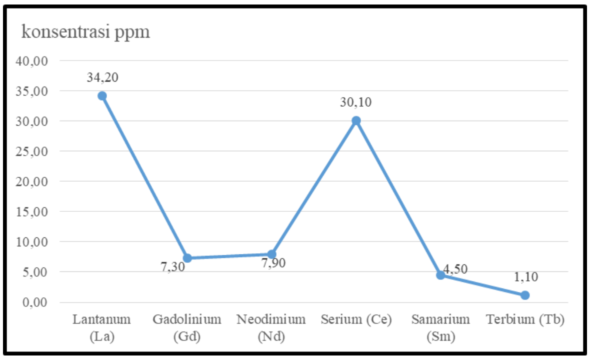

Figure 4. Variation of rare earth metal concentration in bottom ash 2

Rare earth elements are grouped into LREE (Light Rare Earth Elements) or light rare earth metals and HREE (Heavy Rare Earth Elements) or heavy rare earth metals. Light rare earth metals (LREE) are rare earth metal elements with atomic numbers 63 and below, while heavy rare earth metals are rare earth metal elements with atomic numbers 64-71 on the periodic table.

Light rare earth elements include Sc, Y, La, Ce, Pr, Nd, Pm, Sm, and Eu while heavy rare earth elements include Gd, Tb, Dy, Ho, Er, Tm, Yb, and Lu [11]. The table above shows that the results of the analysis of rare earth elements in fly ash and bottom ash are the dominant light rare earth elements.

B. Utilization of rare earth elements

Entering a new era, rare earth elements are the most sought-after and hunted commodities today. Utilization of these rare earth elements is essential because rare earth metals are the trigger that causes the development of new technology, which is quite significant and will continue to grow. The utilization of rare earth elements contained in fly ash and bottom ash, namely cerium, is used as a catalyst converter in automobiles, glass coloring, and steel production. Gadolinium is used as a neo magnet. Lanthanum is a catalyst in various types of batteries, studio lighting, and hybrid car batteries [12]. Neodymium is used as an oil refining catalyst. Samarium is used as an ingredient in the manufacture of solid magnets. These rare earth metals can be extracted further and used as industrial supporting materials in Indonesia. From the various uses of rare earth metals, it can be concluded that this material is a promising material and has the potential to continue to increase in the future.

Meanwhile, the utilization of coal ash waste that has been carried out is mixing fly ash as a tomato growing medium [13], as a material in the manufacture of environmentally friendly perforated concrete bricks [14], and PAF overburden encapsulation in the prevention of acid mine drainage in PT Berau Coal [15].

4. CONCLUSION

The conclusion of this research is

1. The content of rare earth elements in fly ash is Lanthanum (La) = 34.20 to 65.10 ppm; Gadolinium (Gd) = 7.30 to 8.10 ppm; Neodymium (Nd) = 7.90 to 27.60 ppm; Serium (Ce) = 30.10 to 96.60 ppm; Samarium (Sm) = 4.50 to 8.00 ppm; Terbium (Tb) = 1.10 to 1.30 ppm.
2. The content of rare earth elements in bottom ash is Lanthanum (La) = 33.50 to 38.10 ppm; Gadolinium (Gd) = 4.80 to 5.90 ppm; Neodymium (Nd) = 7.90 to 27.60 ppm; Serium (Ce) = 10.90 to 11.00 ppm; Samarium (Sm) of 6.40 to 7.00 ppm; Terbium (Tb) = 1.20 to 1.40 ppm.

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