Analysis Of Eucalyptus (Melaleuca Cajuputi) Characteristics Of Post Coal Mining Land For Bioenergy

Lulu Yuningsih[1,2], Hermansyah[1,3], Eddy Ibrahim[1,4], Marsi[1,5]
{lulu.hutumpalembang@gmail.com}

[1]Graduate School of Enviromental Science, University of Sriwijaya, Jl. Padang Selasa, Bukit Besar, Palembang, South Sumatera, 30139, Indonesia
[2]Forestry Study Program, Muhammadiyah University of Palembang, Jl. Jenderal A. Yani, Plaju, Palembang, South Sumatera, 30263, Indonesia
[3]Department of Chemistry, Faculty of Mathematics and Natural Sciences, University of Sriwijaya, Inderalaya, Ogan Ilir, South Sumatera,30662, Indonesia
[4]Department of Mine, Faculty of Engineering, University of Sriwijaya, kampus Inderalaya, Ogan Ilir, South Sumatera, 30662, Indonesia
[5]Department of Soil, Faculty of Agriculture, University of Sriwijaya, kampus Inderalaya, Ogan Ilir, South Sumatera,30662, Indonesia

Abstract. Eucalyptus (Melaleuca cajuputi) is planted in a post-coal reclamation field, including a type of pioneer due to its rapid growth, ability to live in dry soil, lack of specific growing requirements, and capacity to improve the physical characteristics, chemistry, and biology of the soil. It belongs to a group of plants that provide numerous benefits through the wood or extraction of essential oil from the leaves. This study aimed to analyze the physical properties of the kayu putih as the raw material of bioenergy. The gravimetric analysis method was used based on the SNI standard, and the result of the charcoal briquette and wood pellets was 0.99%. Furthermore, the water content of 33.67% met the charcoal briquins standard. The fixed carbon value was bound to 16.66%, and the calorific value of 4,535 cal/g met the wood SNI standard. The value of the volatile matter was 83.35%, and the analysis results of specific gravity was 0.73 g/cm3, lignin content 31.77%, cellulose 49.68%, and the extractive substance in NaOH, benzene, hot water, and cold water solutions at 16.45%, 4.01%, 8.73%, and 4.68%, respectively.

Keyword: Eucalyptus, Characteristics, Post Coal Mining Land, Bioenergy

1. Intoduction

Post-mine land degradation includes changes in the landscape, physical conditions, chemical and biological soil, microclimate, as well as plants and animals [1]. Excavation of topsoil produces physical soil chemical damage to reach the bottom of a much deeper mine, affecting the topography, soil composition, and surface [2]. To overcome the scenario, the land would need to be rebuilt after the mining. The post-mining land reclamation is an effort to manage, restore and improve the quality of the environment and ecosystems. Therefore, as the first step in creating new ecosystems, the soil surface can be stable and produced from the

SRICOENV 2022, October 05-06, Palembang, Indonesia

DOI 10.4108/eai.5-10-2022.2328330

link between soil and vegetation [3]. One of the post-mining land reclamation programs is the proposed detection activity to form new ecosystems continuously. The simplest strategy to restore productivity, cover vegetation in disturbed areas and improve soil quality and microclimate is “revealed” [4][5].

In marginal land post mines, the type selected for detection needs to be noticed between the kinds of plants and conditions for growth. [6] asserted that the plant-specific characteristics necessary to seize a field are (1) a local kind of pioneer growth quickly; (2) blocking the sun's face (intoleran); (3) producing a large and rapidly degenerated iridescent system; (4) inducing the arrival of a catalogue-bearing crop, and (5) being simple, inexpensive to multiply, cultivate, and maintain.

It is envisaged that land can continue to serve as energy resources once mines are removed by revegetation, thereby preparing energy derived from biomass. The use of biomass as a fuel has the potential to significantly mitigate global warming [7][8].

According to [9], biomass is the fourth largest primary energy source readily available in some developing countries. In addition, the energy source will solve the environmental problems of global warming and increased greenhouse gases caused by industrial activity. Through biomass, photosynthetic plants will absorb CO2 from the atmosphere through stomata and combine it into the biomass organic material. Solar energy may convert CO2 and H2O into carbohydrates and O2 [10][11].

Eucalyptus (Melaleuca cajuputi) is planted in post-mine reclamation fields. The wood was selected as a principal plant in the revulation because it was a pioneer type, being able to live on dry ground and having no specific growing requirements. Rapid growth improved the physical characteristics, chemistry and biology and produced essential oil [12][13]. Furthermore, eucalyptus plants offer many benefits as multi-purpose tree species (MPTS) by extracting the leaves into the oil of atsiri. Harvesting leaves for an extract of attsiri oil is conducted by cutting branches. Leaves are used for atsiri oil, while twigs and branches can be used for bioenergy. This study aimed to analyze the physical characteristics of the eucalyptus raw material as a raw material of bioenergy.

2. Material and Methods

The eucalyptus feedstock of energy came from areas-land areas after the liquidity at IUP TAL PT Bukit Asam, Tbk. A wood sample was taken from the primary branch, followed by a physical-chemical characteristic test. The parameters analyzed are colour, the weight of type, water level, volatile matter, ash content, fixed carbon, lignin, cellulose, and extractive. The parameters and method of analysis used to conduct a character analysis of wood chemical properties are presented in Table 1. The data obtained are comparative analysis with SNI wood charcoal briquettes SNI 01-6235 -2000 and SNI wood pellets SNI 8021-2014. ICS 79.060.01.

Table 1. Parameters and methods of analysis of the chemical-physical characteristics of wood

No	Parameter	Test Methods
1	Calorific value	Instrumentasi
2	Specific gravity	Gravimetry
3	Water content	Gravimetry
4	Volatile matter	Gravimetry
5	Ash content	Gravimetry SNI 14-1031-1989 item 4.1

6	Fixed carbon	100% - (ash content + volatile matter)
7	Lignin	Gravimetri SNI 14-0492-1989
8	Cellulose	Gravimetry
9	Extractive substance in benzene solution	Gravimetry SNI 14-1032-1989
10	Extractive substance in cold water solution	Gravimetry
11	Extractive substances in hot water solution	Gravimetry SNI 01-1305-1989
12	Extractive substance in NaOH solution	Gravimetry SNI 14-1838-1990

3. Results and Discussions

Analysis of the physical characteristics of raw materials (articles cajuputi) covers weight parameters, water levels, ash levels, and volatile matter. Fixed carbon, lignin, cellulose, and colour value are served in Table 2.

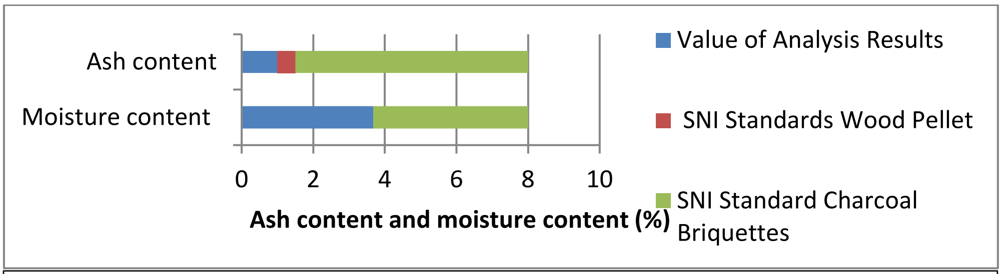
Table 2. Results of the analysis of the chemical physical characteristics eucalyptus (Melaleuca cajuputi)

No	Parameter	Value
1	Specific gravity	0.73g/cm3
2	Water content	3.67%
3	Ash content	0.99%
4	Volatil matter	83.35%
5	Fixed carbon	16.66%
6	lignin	31.77%
7	Cellulose	49.68%
8	Calorific value	4,535 kal/g

The specific gravity value of eucalyptus in the analysis result is 0.73 g/cm3. This value is in the high-density category, as [14], stated that wood with a greater weight than 0.57 g/cm3 is considered the most fit for charcoal production. It produces charcoal with high productivity and nearly 0.4 g/cm3. The weight of the wood could represent wood or bulk density. Specific gravity value affects wood for charcoal or other energy. A high degree of weight may indicate the time of burning a stick [15].

The analysis of eucalyptus showed a water content of 3.67%. This value is below 8%, which is the threshold for meeting the SNI 01-6235-2000 standard for coal quality appropriate for energy production [16]. The fulfilment of the water standard of quality value to the charcoal briquins is presented in Figure 1. This harmonizes with [17] that the value of the range of water levels of wooden materials is between 8% - 12%. The water level is one of the basic characteristics of wood that affects the caloric value. The higher the fuel's water content, the lower the value produced [18]. In the conversion process, it takes much energy to remove water from the wood into steam, thereby reducing the energy in the fuel [19].

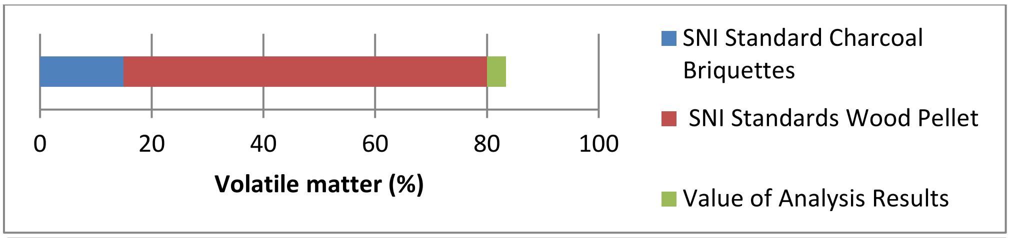
The value of the eucalyptus ash content analysis is 0.99%. Judging by the content value as a condition of the wood pellet quality, eucalyptus meets the standard because it has a value of <1.5% [20]. Similarly, when the raw materials are used as charcoal briquins for energy, it also meets the standard since it has a high value of <8%. The difference between the two figures, which represent the value of the ash levels, is less pronounced than in Figure 1. Wood with high levels of ash tends to have inorganic fractions. Due to the retarded rate of combustion caused by the inorganic particle's incombustibility the amount of wood used for energy is lowered [21][22].



	Moisture content (%)	Ash content (%)
Value of Analysis Results	3.67	0.99
SNI Standard Wood pellet		1.5
SNI Standard Charcoal Briquettes	8	8

Figure 1. Compliance with the standards of ash content and moisture quality values against the SNI values of wood pellets and charcoal briquettes

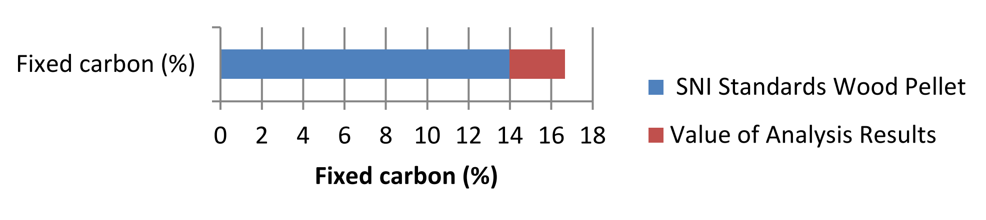
The eucalyptus volatile matter value is 83.35. The value of the volatile matter compared with the SNI's requirements for charcoal briquins and wood pellets has not met the standard. This is because they have exceeded 80% for the SNI wood pellets and 15% for the charcoal briquins. The quality value fulfilment of the flying substance to the enrichment scale and the wood pellets are presented in Figure 2. Volatile matter indicates many volatile compounds or substances [23]. It is formed due to thermal degradation from a wood chemical component of methane, hydrocarbon, hydrogen, and nitrogen compounds.



	Volatile matter (%)
SNI Standard Charcoal Briquettes	15
SNI Standard Wood pellet	80
Value of Analysis Results	83.35

Figure 2. Wood pellets and charcoal briquettes

The fixed carbon proportion of eucalyptus is 16.66%. This value qualifies as the building block of energy for wood pellets, compared with the standards of quality wood based on this scale >14%. The fulfilment of a carbon-quality value standard is tied to the SNI wood pellet served in Figure 3. It is in line with [17], that fixed carbon levels are tied in biomass for minimum energy raw materials have a fixed carbon of 16%. The fixed carbon value is directly proportional to the energy wood quality and the caloric value.



	Fixed carbon (%)
SNI Standard Wood pellet	14
Value of Analysis Results	16.66

Figure 3. SNI value of wood pellets and charcoal briquettes

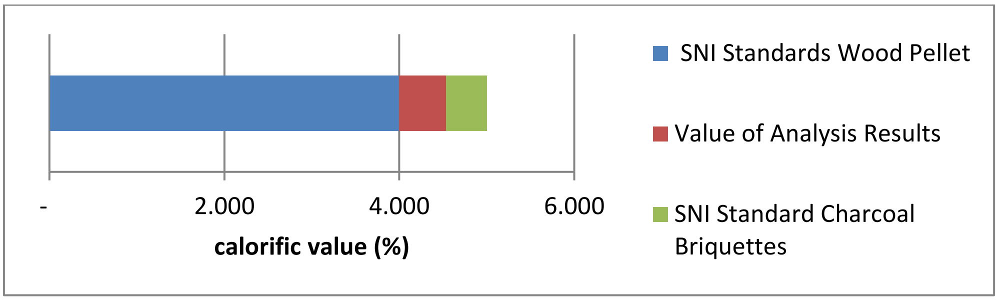
The eucalyptus lignin and cellulose content analysis is 31.77% and 49.68%. Higher levels of lignin and cellulose are preferable to use as a charcoal energy wood [21]. Lignin determines the properties of rigidity and can be colorally degraded at high temperatures to 400 compounds shown with combustion residue or thermal degradation of berlignocellulose [24]. The degraded lignin and cellulose abilities of high temperatures provide the advantage of using wood as charcoal. High levels of these contents will also affect carbon levels attached to energy sources.

The data is presented with the analysis results of the eucalyptus value with cool water, hot water, NaOH, and benzene ranging from 4.01% - 16.45% in Table 3. Extractive as a cell cavity is composed of substances such as sugar, starch, tannin, pectin, woody colors, acidic, oil, and fat, which can be isolated using organic solvents and water [25]. The existence of extractive substances is also vital for using biomass as energy. [26] reported that the presence of extractive substances plays an important role in the caloric value produced. Therefore, biomass's level of extractive matter will result in a high calor value.

Table 3. The value of eucalyptus (Melaleuca cajuputi) extractive on various solvents

No	Parameter	Value
1	Extractive substance in cold water solution	4.68%
2	Extractive substances in hot water solution	8.73%
3	Extractive substance in NaOH solution	16.45%
4	Extractive substance in benzene solution	4.01%

The eucalyptus caloric value is 4.535 cal/g. This value has already met the wood pellet energy standard since the analysis value has met the SNI standard with the value of 4,000 kal/g. However, it has not met the standard to be used as a charcoal bric-based source. The caloric value contained in the raw materials of eucalyptus is high. [17] stated that the wood caloric is in the range of 4.396 cal/g. The production of a by-product value standard on the SNI of the wood pellet and charcoal briquettes is presented in Figure 4. The caloric value is the heat produced by the combustion of energy materials and is the primary parameter for assessing the quality of the energy item [19]. The caloric value is affected by water levels, extracts, wood chemistry, and the type of wood [26].



	calorific value (kal/g)
SNI Standard Wood pellet	4,000
Value of Analysis Results	4,535
SNI Standard Charcoal Briquettes	5,000

Figure 4. Fulfilment of calorific value standards to the SNI value of wood pellets

4. Conclusion

The eucalyptus (Melaleuca cajuputi) raw material has the water content of 33.67% met the charcoal briquins standard. The fixed carbon value was bound to 16.66%, and the calorific value of 4,535 cal/g met the wood SNI standard. The value of the volatile matter was 83.35%, and the analysis results of specific gravity was 0.73 g/cm3, lignin content 31.77%, cellulose 49.68%, and the extractive substance in NaOH, benzene, hot water, and cold water solutions at 16.45%, 4.01%, 8.73%, and 4.68%, respectively.

5. Acknowledgement

The research of this article was funded by DIPA of Public Service Agency of Universitas Sriwijaya 2022 SP DIPA-023.17.2.677515/2022, on December 13, 2021. In accordance with the Rector's Decree Number : 0111/UN9.3.1/SK/2022, on April 28, 2022.

References

[1] B. Prasetyo, B. D. Krisnayanti, W. H. Utomo, and C. W. N. Anderson, "Rehabilitation of Artisanal Mining Gold Land in West Lombok, Indonesia: 2. Arbuscular Mycorrhiza Status of Tailings and Surrounding Soils," J. Agric. Sci., vol. 2, no. 2, pp. 1–7, 2010, doi: 10.5539/jas.v2n2p202.

[2] S. Herjuna, "Pemanfaatan Bahan Humat dan Abu Terbang untuk Reklamasi Lahan Bekas Tambang . Tesis. Sekolah Pasca Sarjana. IPB. Bogor. (2011)," p. 2011, 2011.

[3] Y. Setiadi and Adinda, "Evaluasi Pertumbuhan Pohon di Lokasi Revegetasi Lahan Pasca Tambang PT. Vale Indonesia Tbk. Sorowako, Sulawesi Selatan," J. Silvikultur Trop., vol. 04, no. April, pp. 19–22, 2013.

[4] A. N. Singh, A. S. Raghubanshi, and J. S. Singh, “Plantations as a Tool for Mine Spoil Restoration,” Current Science, vol. 82, no. 12. pp. 1436–1441, 2002.
[5] V. Sheoran, A. Sheoran, and P. Poonia, “Soil Reclamation of Abandoned Mine Land by Revegetation: A Review,” Int. J. Soil, Sediment Water, vol. 3, no. 2, pp. 1–20, 2010.
[6] S. Oktorina, “Kebijakan Reklamasi dan Revegetasi Lahan Bekas Tambang (Studi Kasus Tambang Batubara Indonesia),” Al-Ard J. Tek. Lingkung., vol. 4, no. 1, pp. 16–20, 2018, doi: 10.29080/alard.v4i1.411.
[7] F. P. Qian, C. S. Chyang, K. S. Huang, and J. Tso, “Combustion and NO emission of high nitrogen content biomass in a pilot-scale vortexing fluidized bed combustor,” Bioresour. Technol., vol. 102, no. 2, pp. 1892–1898, 2011, doi: 10.1016/j.biortech.2010.08.008.
[8] W. C. Chou, C. S., Lin, S. H., Peng, C. C., & Lu, “The optimum conditions for preparing solid fuel briquette of rice straw by a piston-mold process using the Taguchi method.,” vol. 90, pp. 12–42, 2009.
[9] M. X. Shen, D. K., Gu, S., Luo, K. H., Bridgwater, A. V, & Fang, “Kinetic study on thermal decomposition of woods in oxidative environment,” vol. 88, no. 6, pp. 12–42, 2009.
[10] M. L. Campbell, N., Reece JB, “Biologi Jilid 3.” Jakarta, 2004.
[11] W. A. Centre, Pengukuran cadangan karbon. 2011.
[12] M. I. C. Juliarti, Wijayanto A., Trikoesoemaningtyas N., “(Melaleuca cajuputi (L.) Powell.) and Citronella (Cymbopogon nardus (L.) Rendle.) Agroforestry in Ex-Coal Mining Reclamation Land,” p. 2021, 2021.
[13] S. R. Jannah, G. M. Hatta, and Basir, “Kesehatan Tanaman Kayu Putih (Melaleuca leucadendra Linn) di Batu Desa Tebing Siring Pelaihari Kabupaten Tanah LautT Health Of Eucalyptus Plant (Melaleuca Leucadendra Linn) In Rehabilitation Land In River Flow (Das) Mountain Batu Village Tebing Siri,” J. sylva Sci., vol. 05, no. 2, pp. 292–300, 2022.
[14] M. Douglas et al., “Charcoal productivity and quality parameters for reliable classi fi cation of Eucalyptus clones from Brazilian energy forests,” vol. 164, 2021, doi: 10.1016/j.renene.2020.09.057.
[15] E. E. Koeslulat, T. A. Prayitno, J. P. G. Sutapa, and D. Irawati, “Karakteristik Energi Tiga Jenis Pohon Cepat Tumbuh Pada Tiga Kelas Diameter,” J. Agrofor., vol. 1, no. XI, 2016.
[16] Badan Standardisasi Nasional, “Briket arang kayu,” Jakarta, 2000.
[17] R. Stahl, E. Henrich, H . Gehrmann, S. Vodegel, and M. Koch, “Definition of a standard biomass,” Germany, 2006. [Online]. Available: https://www.google.com/%0Apapers2://publication/uuid/91641A1B-4536-46A1-BE5A-43C0F036A447
[18] M. Mancini and Å. Rinnan, “Near infrared technique as a tool for the rapid assessment of waste wood quality for energy applications,” Renew. Energy, vol. 177, pp. 113–123, 2021, doi: 10.1016/j.renene.2021.05.137.
[19] E. Vitriandhani, “Sifat Proksimat dan Kadar Lignin Kayu Tekan Pinus (Pinus merkusii Jungh Et De Vriese) sebagai Bahan Baku Energi Biomassa,” Institut Pertanian Bogor, 2019.
[20] B. S. Nasional, “Pelet Kayu.” Jakarta, 2014.
[21] N. Hastuti, L. Efiyanti, G. Pari, and D. Setiawan, “Komponen Kimia dan Potensi Penggunaan Lima Jenis Kayu Kurang Dikenal Asal Jawa Barat,” J. Penelit. Has. Hutan, vol. 35, no. 1, pp. 15–27, 2017.
[22] L. Efiyanti, S. A. Wati, D. Setiawan, and G. Pari, “Sifat Kimia dan Kualitas Arang Lima Jenis Kayu Asal Kalimantan Barat,” J. Penelit. Has. Hutan, vol. 38, no. 1, pp. 55–68, 2020.
[23] S. L. Gusvina, “Sifat Kimia dan Proksimat Biomassa Lima Jenis Kulit Kayu,” Institut Pertanian Bogor, 2017.
[24] N. Hastuti, K. Kanomata, and T. Kitaoka, “Hydrochloric Acid Hydrolysis of Pulps from Oil Palm Empty Fruit Bunches to Produce Cellulose Nanocrystals,” J. Polym. Environ., vol. 26, no. 9, pp. 3698–3709, 2018, doi: 10.1007/s10924-018-1248-x.
[25] D. Fengel and G. Wegener, Wood: chemistry, ultrastructure, reactions. Walter de Gruyter, 2011.
[26] P. Basu, Biomass gasification and pyrolysis: practical design and theory. Academic press, 2010.