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The Potential of Biomass from Wood, Leaves, and Grass as Renewable Energy Sources in South Sumatera, Indonesia

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South Sumatera Province has vast forests with a diversity of crops potential for biomass fuel. A biomass-based energy source is one of the options to meet the energy needs for human life. This study aims to assess the potential of biomass from wood, leaves, and grass as a source of renewable energy, such as firewood and charcoal. The basic properties of biomass fuels, including calorific value, sulfur content, the flame temperature, and flue gas emissions are presented in this article.

Keywords: biomass, herbaneous, renewable energy, South Sumatera, wood

INTRODUCTION

Fuel oil obtained from crude oil petroleum, which is processed in the form of gasoline, diesel, and kerosene, is a non-renewable fuel. It takes millions of years to recycle it back and it pollutes the environment with greenhouse effect. Its continuity of supply is not guaranteed and non-sustainable. If there is no change in the pattern of domestic consumption of fuel oil in South Sumatera, its reserves are estimated to run out in less than 200 years. In such conditions, any attempted strategy, such as savings, efficiency, and use of advanced technology, will not be effective (NTBD, 2007).

Decreasing natural resources, such as petroleum reserves, causes energy experts to look for other alternative energy sources. Some alternative energy sources, such as solar energy, micro hydro power plants, and vegetable oils, have been derived from plants and crops (biofuels). Wood, leaves, and agricultural waste (biomass-wood and herbaneous) have also been utilized. Utilization of energy resources can be adapted to existing natural resources.

Agricultural residues are potential renewable energy resources that can be converted to biofuels, such as bio-oil from pyrolysis, bio-char from carbonization and slow pyrolysis processes, and biogas from anaerobic digestion (Demirbas, 2007).

Biomass and the Environment

Uncontrolled use of energy causes environmental damage due to emissions of fuel combustion. The Kyoto Protocol set targets for emission limits in the 2008 to 2012 period that should be 12.5%

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lower than the limit in 1990 (DEFRA, 2005). This indicates a greater burden to be faced by humans. An increase in industrial activities and other activities of human life result in increased pollution. Utilization of wood, leaves, as well as agricultural waste, deserves to be studied further. Felling trees of the forest illegally raises many problems. One of them is the branches, twigs, and leaves that will be wasted and mostly burned as the quickest way to clean the work environment. Such is the case with the results of the agricultural industry, which makes abundantly available waste in the form of leaves and stems. Moreover, wild plants that contribute to environmental degradation can also be utilized as an energy source.

Three important biomass materials can be extracted as plant-based energy sources. First, branches and twigs from jati, akasia, and pelawan trees harvested, for example, can be harnessed as an energy source. Trees with low selling value that can be planted en masse, such as gelam trees, and trees that reach the age of such unproductive yields, such karet trees, can also be included as a renewable energy source. Second, many agricultural industrial wastes, such as banana leaves of banana plantations and corn leaves of corn plantations, can be used as a source of biomass energy. Third, ilalang grass and eceng gondok, a nuisance weed widely available throughout South Sumatera environment, can also be used as a biomass energy source. As sources of biomass energy, all three groups can be used directly as firewood, which burns without going through any other process first. Due to third combustion exhaust gas emissions, these three sources of biomass energy need further assessment.

This study is an attempt to review the potential of existing plants in South Sumatera Province; it presents the primary data source for renewable energy of this type of solid fuel. It discusses the main elements for the classification of fuels, including: the proximate, calorific value, the emission of gases of combustion, and temperatures that can be generated.

A previous study measured and analyzed some wood materials, such as akasia, gelam, jati, karet, meranti, and pelawan (Nukman, 2009). That study has been further developed in this study, by adding other types of wood and by adding a measure of the combustion temperature for all materials. However, in this study meranti was not considered for further investigation because it is a rare type of, which is hard to obtain.

Biomass Energy Policy in Indonesia

World energy consumption from 1980 to 2003 experienced an average increase of 33% and saw the projection of energy consumption increase by an average of 43.75% (EIA, 2006); the world fossil energy consumption increased by 80% in 1980 and it has been targeted to be replaced with biomass energy (Faaij, 2006). For Indonesia, the development of biomass energy is included in the energy-increasing role of new and renewable energy, including biomass, nuclear, biofuels, solar energy, and wind. The Ministry of Energy and Mineral Resources of Indonesia (2006) has made a Blueprint for National Energy Management 2006–2025 for further development. The role of new energy and renewable energy will be increased to 5% by 2025.

Exhaust Emissions

Exhaust gases of combustion that affect the environment are: carbon monoxide (CO), which is poisonous, or carbon dioxide (CO_2), which is a greenhouse gas; nitrogen oxide compounds (NO_x); and compound hydro carbon (HC), which is due to incomplete combustion processes. As the incidence of burning farms, garbage, and other combustion is performed with a specific purpose, it would generate exhaust emissions as a potential pollutant.

The study of biomass burning in the combustor and emissions have been conducted by several researchers (Khor et al., 2007; Madhiyanon et al., 2009).

Biomass Materials

In this study, two main sources of biomass material were analyzed:

a. Wood: akasia, pelawan, gelam, jati, karet, tembesu, nangka, kelapa, and jambu;
b. Leaves of plants and wild plants: straw + husk, corn leaves, banana leaves, ilalang, and enceng gondok.

Most of these materials can be used for secondary needs. Akasia and jati woods have been used as furniture materials at a reasonable price. Waste from both, such as the dust of sawmills, wood stump, branches, twigs, and leaves, can be used as an alternative fuel. Pelawan and gelam show properties of different strengths, but both have been in common use in the life of the South Sumatera community. Pelawan is a good firewood, while gelam viewed from its ease of growing (grows in acidic soil) has potential for further development as a fuel.

Fossil fuel reserves in the world are decreasing; however, natural resources in South Sumatera are abundant. Plants and sewage waste become useless and have not been fully utilized. Therefore, this study is important in a way and it provides new information for an alternative energy source.

Some of data obtained from this study is the result of previous research. The materials were extracted from plant sources grown in South Sumatera Province. They were analyzed in the laboratory and tested for their basic properties and measured temperatures; they were expected to dump gas emissions still within the specified threshold.

MATERIALS AND METHODS

The wood materials were dried in the sun and cut with a chainsaw. Thus, forms of sawdust were obtained. The wood powder was ground in a mortar and then sieved in a size 60 mesh fineness. Grasses and leaves for biomass were dried and then cut with scissors and pulverized using a grinder. Fineness of powder size was 60 mesh.

This study consisted of two stages and focused on the identification of the materials. The first stage was the identification of the main properties of the materials, including proximate analysis (such as content: moisture, volatile matter, fixed carbon, and ash), sulfur testing, and testing of calorific value. The second stage was the measuring of the flame temperature and testing of gas emission. The biomass materials were burned in a fixed bed combustor. The tool designed specifically in a laboratory scale consists of the main cylinder where the combustion took place and is equipped with smoke flow pipe support equipment.

The materials were burned in a container outside the cylinder and the flame was kept stable. After, it was inserted into the main cylinder and the primary air flow from the bottom of the combustor. This resulted in elevated rates of heat exchange in a fixed bed combustor. Flame temperature readings were done by inserting a thermocouple probe to measure the hole. Hot combustion gases flow out of the combustion chamber through a pipe to measure CO and NOx emissions.

RESULTS AND DISCUSSION

Proximate Analysis and Sulfur Content

In this study, bark is part of the wood. As for the type herbaneous, the roots of plants are included as part of the test material. The tests were conducted after the warming of all samples in the hot sun for 2 days.

Figure 1 shows three main components of the measurement results of moisture, volatile matter, and ash, while fixed carbon is the result of the difference from 100% material. The greatest moisture levels are found in samples of karet wood by 13.20% and the smallest is found in straw by 7.20%. Moisture content is one component that affects the ease of burning material. Higher levels of moisture result in the initial combustion duration. The greatest level of volatile matter is contained in the tembesu wood of 76.10% and the smallest is in the straw, which is equal to 58.30%. The content of volatile matter is a combination of several materials, such as light hydrocarbon gases, carbon monoxide, carbon dioxide, hydrogen, water, and tars. The content of volatile matter, such as light hydrocarbon component, is early incendiary material; it is a very important component for combustion. In other words, the combustion is dependent on the content of volatile matter. The amount of the content of these components is necessary for combustion gases in combustion systems of firewood. Thus the measurements of the component data are useful for firewood combustion. The size of the largest ash content is contained in the straw by 19.84%, whereas 0.36% is for the smallest found in merawan wood. Therefore, it can be said that straw is the biggest burning waste and merawan wood produces the smallest waste. On the other hand, the amount of fly ash content will inhibit the rate of combustion. This measurement indicates a maximum sulfur content of 0.17% for karet wood, straw, and nangka wood; they have minimal sulfur content and the same amount of 0.04%. The presence of sulfur in the wood material is not expected and because of the burning, sulfur will change to SO_2 and this is a detriment to the environment.

Calorific Value and Temperature Measurement of Combustion

Figure 2 shows two measurement results: calorific value and the temperature of combustion. The calorific value shows the magnitude of the heat content per weight of material, while the

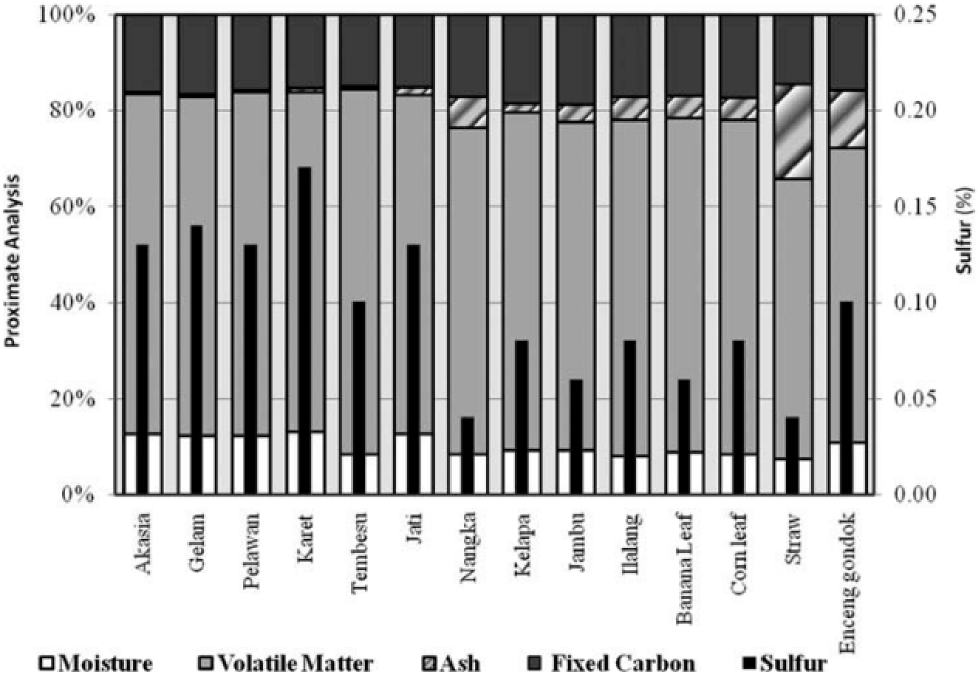

FIGURE 1 The proximate and sulfur of biomass.

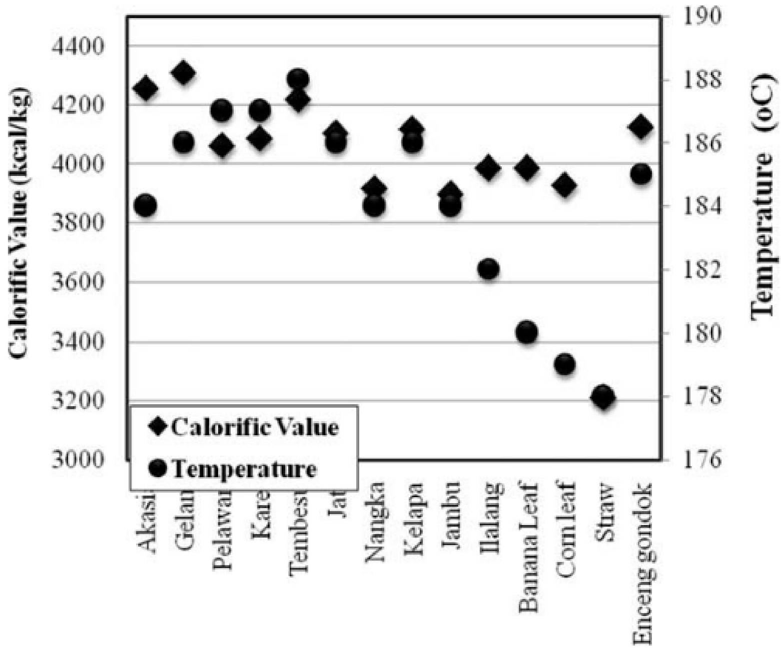

FIGURE 2 Calorific values and temperatures of biomass.

temperature was measured with a distance of 175 mm from the container material being burned, or the top of the flames. Temperature measurements were performed three times, and the values shown in Figure 2 are the average values.

Gelam wood has a calorific value of 4,308 kcal/kg, which is the largest, and eceng gondok has the lowest at 3,124 kcal/kg. Figure 2 shows that gelam wood burns at 186°C. Although enceng gondok has the lowest calorific value, it has a large fuel temperature that is equal to 185°C. Tembesu wood shows the highest temperature of 187°C, and jerami the lowest that is 178°C. Therefore, Figure 2 shows that the high calorific value of a wood is not followed by a high temperature, whereas the lowest calorific value is followed by the lowest temperatures.

Measurement of Exhaust Emissions Combustion Products

Measurement of exhaust emissions were performed in conjunction with the material temperature. Figure 3 shows the results of measuring exhaust emissions levels, that is for CO and NO_2 levels. The biggest CO levels were obtained from the burning of karet wood, which is equal to 140 ppm, and the lowest at 128 ppm of enceng gondok. Kelapa wood provided the greatest pollutant NO_2 of 312 ppm, while the lowest exhaust emissions test results for NO_2 were measured at 288 ppm of gelam wood.

CONCLUSION

Because its sulfur content is low, biomass energy can be relied upon as an environmentally friendly alternative energy. In addition to calorific values, the temperature and combustion emissions can also be considered as a material consideration for the selection of biomass as a fuel. Since tembesu

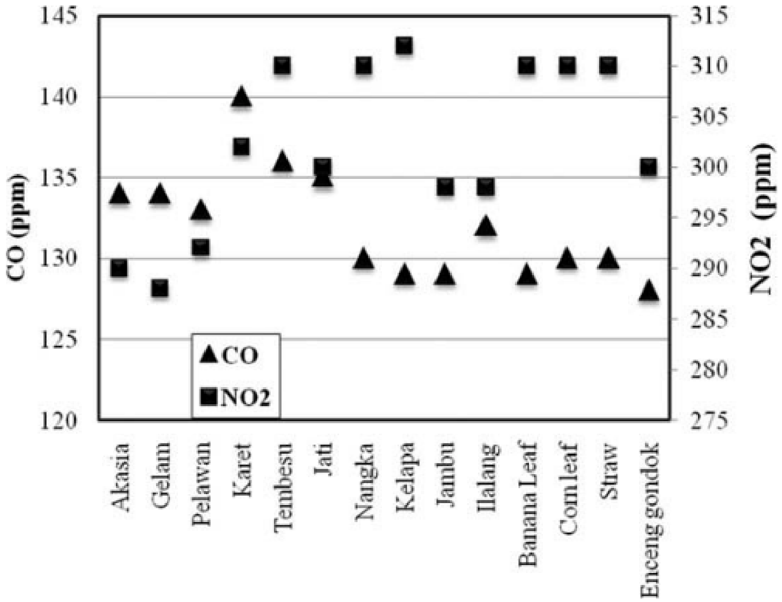

FIGURE 3 Exhaust emissions of combustion biomass.

wood has the largest volatile matter in the presence of light hydrocarbon gas content, this wood can be considered for cultivation. Moreover, they can be grown quickly and easily.

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