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Chemical Characteristics of Palm Frond and Empty Fruit Bunch Biochar in Pyrolysis Method

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ABSTRACT
Indonesia's palm oil production continues to increase. The increase in palm oil production has implications for the high amount of waste generated in the form of solid and liquid waste. Solid waste that is produced is fronds and empty bunches. So far, the utilization of frond and empty bunch waste has not been maximized, so that its presence in the oil palm plantation area accumulates and tends to interfere with oil palm maintenance and harvesting activities. Processing the waste of fronds and empty bunches with pyrolysis method to make biochar can be the right solution to maximize the use value of these wastes. Biochar has many benefits for soil and plants such as soil improver that can effectively increase soil pH and CEC. In addition, it can help bind nutrients in the soil so that they become available to plants. The purpose of this study was to determine the chemical characteristics of biochar waste fronds and empty bunches. The results of chemical tests of palm frond biochar and empty palm bunches obtained the results of N, P, K, C/N, Ash Content, pH, and C-Organic respectively of 0.47%, 0.04%, 0.96%, 4.86%, 7.96, and 50.18% on palm frond biochar and 0.91%, 0.03%, 0.67%, 7,18%, 6.31 %, and 58.04% on empty palm bunches. These results meet the requirements of SNI 06-3730-1995 to be applied to soil.
Keyword: Palm Oil, Biochar, Bunch, Empty Palm Oil

ABSTRAK
Produksi kelapa sawit Indonesia terus mengalami peningkatan. Peningkatan produksi kelapa sawit berimplikasi pada tingginya jumlah limbah yang dihasilkan berupa limbah padat dan cair. Limbah padat yang banyak dihasilkan yaitu pelepah dan tandan kosong. Sejauh ini pemanfaatan limbah pelepah dan tandan kosong belum maksimal, sehingga keberadaannya di areal perkebunan kelapa sawit menumpuk dan cenderung mengganggu aktivitas perawatan dan pemanenan kelapa sawit. Pengolahan limbah pelepah dan tandan kosong dengan metode pirolisis untuk dijadikan biochar dapat menjadi solusi yang tepat untuk memaksimalkan nilai guna dari limbah tersebut. Biochar memiliki banyak manfaat bagi tanah maupun tanaman seperti bahan pembenah tanah yang secara efektif dapat meningkatkan pH dan KTK tanah. Selain itu dapat membantu mengikat unsur hara di dalam tanah agar menjadi tersedia bagi tanaman. Tujuan penelitian ini adalah untuk mengetahui karakteristik kimia biochar limbah pelepah dan tandan kosong kelapa sawit. Hasil uji kimia biochar pelepah dan tandan kosong kelapa sawit didapatkan hasil N,P,K, Kadar Abu, pH, dan C-Organik masing-masing 0.47%, 0.04%, 0.96%, 4.86%, 7.96, dan 50.18% pada biochar pelepah kelapa sawit dan 0.91%, 0.03%, 0.67%, 7,18%, 6.31 % pada tandan kosong kelapa sawit. Hasil tersebut memenuhi persyaratan SNI 06-3730-1995 untuk diaplikasikan pada tanah.
Keyword: Kelapa Sawit, Pelepah, Tandan Kosong

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1. Introduction

Indonesia is the main producer of oil palm after Malaysia [1]. Area of oil palm plantations in Indonesia, especially Lamandau Regency, Central Kalimantan, continues to increase with a total area of 72,933 hectares with a total production of 80,501 tons [2]. The increase in oil palm area and production has implications for the increase in waste generated. Waste generated in oil palm plantation practices can be in the form of solid waste and liquid waste. Solid waste that has not been widely utilized is palm fronds and empty bunches. Oil palm empty fruit bunches (TKKS) are one of the solid wastes of oil palm that have not been utilized effectively [3]. The utilization of TKKS is currently more on direct application in oil palm plantation areas which causes adverse impacts such as becoming a habitat for horn beetle pests that have the potential to cause damage to oil palm plants. In addition, a lot of solid waste is produced, namely palm fronds.

A lot of solid waste is generated from oil palm plantations and has not been utilized properly, namely palm fronds [4]. The existence of oil palm fronds in the plantation area continues to accumulate and disrupt the process of maintaining and harvesting oil palm. Palm fronds can potentially be processed into biochar to improve soil fertility. Biochar can increase soil retention by improving soil fertility [5].

Processing palm frond waste and empty fruit bunches into biochar by pyrolysis method is the right solution to increase the use value of these wastes because the pyrolysis method is carried out without causing air pollution (smoke) as in open burning processing. Pyrolysis method is a biomass conversion process with high temperatures without oxygen [3]. The results of this pyrolysis are in the form of charcoal and liquid smoke or more widely known as bio-oil. Biochar produced in the pyrolysis process has many benefits to increase nutrient retention (N, P, K, Mg) and soil water retention [6], improve soil CEC and pH [7], play an important role for soil fertility and nutrient absorption, especially nitrogen [8]. Biochar application can increase pH and C-organic in ultisol soil and can increase N and P uptake in corn plants [9]. Biochar can remediate heavy metal Cd [10]. Biochar produced from plant biomass can significantly remediate heavy metals [11].

Besides producing biochar, the pyrolysis reactor also produces liquid smoke which has many benefits. Liquid smoke is produced in a cooling condenser installation where the smoke generated from burning waste palm fronds and empty bunches is flowed into the condenser pipe and the smoke will be condensed into liquid smoke. Liquid smoke contains phenol and acetic acid which are rich in antioxidants and antibacterials [12]. Palm empty fruit bunch liquid smoke contains phenol and acetic acid compounds that can be used as a vegetable insecticide for Plutella xylostella L., Spodoptera litura, Plusia spp, and Crocidolomia binotalis [13]. This study aims to determine the chemical characteristics (N,P,K, C/N Ratio, C-Organic, and pH) of biochar from frond waste and empty palm bunches.

2. Materials and Methods

2.1. Materials

The materials used are palm fronds, empty palm bunches, reactor water and LPG gas. As for the tools used are biochar reactor/installation, liquid smoke container, high pressure gas stove, mortar, plastic sample, 300 ml sample bottle, key 12, blender and plastic bottle.

2.2. Methods

This research was conducted from March to June 2024. The production of biochar from palm fronds and empty fruit bunches was conducted in the plantation waste installation room of Lamandau Polytechnic. Analysis was conducted at the Plantation Crop Production Technology Laboratory of Lamandau Polytechnic and Sulung Research Station Laboratory. The steps taken in this research are.

2.2.1 Manufacture of biochar installation

The first step was to build a biochar installation (Figure 1). The biochar installation is made based on the pyrolysis principle where the combustion process is closed. Pyrolysis technology consists of several methods such as the manual method, the Kiln method, and Retort method [14]. The quality of biochar depends on the pyrolysis process that takes place such as temperature and the raw materials used, and each biochar raw material has its own advantages [15]. In this study using biochar installation using the Retort pyrolysis method. The Retort method is considered to produce better chemical characteristics than the other methods [14]. The Retort pyrolysis method uses a modified tube with a cooling tube to produce liquid smoke from the combustion of raw materials. This installation consists of 3 main tubes: a biomass combustion tube, a high temperature stove tube, and a cooling tube.

Indonesian Journal of Pharmaceutical and Clinical Research Vol.02, No.01 (2024) 028–033

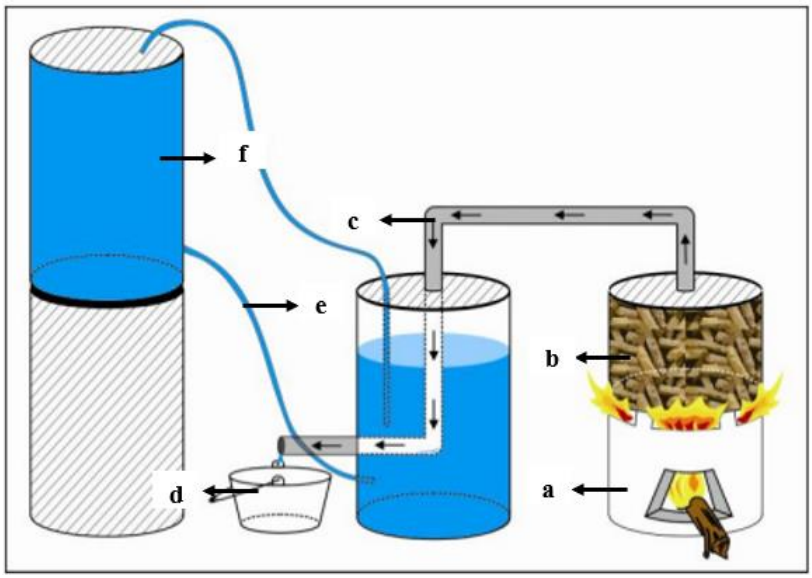

Figure 1. Biochar installation with a) stove tube, b) biomass burning tube, c) cooling pipe, d) liquid smoke collection container, e) circulation hose, f) circulating water tube.

2.2.2 Biochar production

The method of making palm oil waste biochar starts with cutting empty bunches and palm fronds into smaller parts to speed up the biochar making process then burning. The process of making biochar in this research is:

1. The biochar feedstock is put into the kiln and then sealed. The combustion fire is turned on with a temperature between 100- 3000C for 4-6 hours (depending on the raw materials used).
2. Prepare a bucket to collect liquid smoke in the liquid smoke output pipe.
3. The combustion fire is turned off and the furnace is allowed to cool (more than 12 hours) and then opened. After that the biochar is unloaded and the biochar smoothing process is carried out.

2.2.3 Biochar content analysis

The research conducted laboratory analysis of 2 types of biochar produced, namely empty bunches, shells, and palm fronds which include analysis of nitrogen (N), phosphorus (F), potassium (K), pH, C-Organic, C/N Ratio, and ash content.

3. Results and Discussion

The results of the research on making biochar of palm fronds and empty fruit bunches were carried out with a combustion temperature of 3000C for 6 hours. The biochar was left in the biomass combustion tube for 10 hours and then disassembled and pulverized. The texture of oil palm frond biochar after pulverization (Figure 2) tends to be finer than that of oil palm empty fruit bunch biochar (Figure 3). The cooling tube produced liquid smoke (Figure 4). The results of laboratory analysis of two types of biochar with parameters of total N, total P, total K, ash content, pH, and C-Organic in Table 1.

Table 1. Chemical properties analysis of palm frond and empty fruit bunch biochar

Test Parameters	Units	Biochar		Test Method
		Frond	Empty Bunch	
N Total	(%)	0,47	0,91	Kjeldahl
P Total	(%)	0,04	0,03	Spectrophotometry
K Total	(%)	0,96	0,67	Flamephotometry (AAS)
Ash Content	(%)	4,86	7,18	Gravimetry
pH	-	7,96	6,31	pH Meter
C-Organik	(%)	50,18	58,04	Gravimetry

Indonesian Journal of Pharmaceutical and Clinical Research Vol.02, No.01 (2024) 028–033

(a) (b)

Figure 2. Biochar of palm fronds (a) before, and (b) after pulverized

(a) (b)

Figure 3. Biochar empty bunces palm oil (a) before, and (b) after pulverized

(a) (b)

Figure 4. Liquid smoke (a) empty fruit bunches, (b) oil palm fronds

3.1. N Total

The N content in empty bunch biochar and oil palm frond biochar is still relatively low with respective values of 0.91% and 0.47%. The pyrolysis process causes the N element to be lost or reduced due to evaporation, so it is necessary to enrich N considering that the N element plays an important role in plant growth [16].

3.2. P Total

Total P in biochar of palm fronds and empty fruit bunches has a value of 0.04 and 0.03, respectively. These results show that the value is still very low. The low amount of P is determined by the amount of organic matter used for biochar [4]. The low P content in biochar is due to the lack of organic P substrates in the biochar itself,

because the P content in biochar can be formed due to the mineralization process that requires the enzyme phosphatase [17].

3.3. K Total

The total K content in the biochar of palm fronds and empty fruit bunches showed optimum results with values of 0.96% and 0.67%, respectively. These results indicate that the K content of frond biochar is higher than that of oil palm empty fruit bunch biochar. One thing that affects the K content of biochar is the moisture content of the raw materials used. The lower the moisture content of raw materials, the higher the K content of biochar. In this study, oil palm empty bunches were still not perfectly dry before the pyrolysis process, while the oil palm fronds were already in a perfectly dry state. This will certainly affect the moisture content of biochar. The quality of biochar is determined by the raw materials [17], pyrolysis process [18] [14].

3.4. Ash Content

The ash content in the biochar of palm fronds and empty fruit bunches has a value of 4.86% and 7.18%, respectively. The ash content of both biochars meets the requirements of activated carbon based on SNI 06-3730-1995, which is a maximum of 10%. Ash content testing is a very important activity in assessing the quality of biochar before it is applied to the soil. Ash content testing aims to determine the quality of activated carbon by knowing the content of metal oxides in activated carbon that cannot evaporate (non-volatile) in the carbonization process [19]. High ash content causes a decrease in the quality of charcoal [20] [21].

3.5. pH

The pH value of palm frond and empty fruit bunch biochar is 7.96 and 6.31, respectively. This value meets the IBI Standard set which is pH ranging from 6-10. Many things can affect the pH of biochar, such as pyrolysis temperature and the age of the material used [22].

3.6. C-Organik

The results of research on C-organic biochar of empty palm bunches are higher (58.04%) than biochar of oil palm fronds (50.18%). This is because oil palm fronds have little biomass compared to oil palm empty bunches. The C-organic value is determined by the organic raw materials used as biochar, which generally contains carbon, oxygen, oxygen, and other mineral elements [22].

4. Conclution

Utilization of palm frond and empty fruit bunch waste into biochar is an effective approach for environmentally friendly organic waste management through pyrolysis method. The results of the characterization of chemical properties (N, P, K, pH, ash content, and C-organic) of palm frond and empty fruit bunch waste biochar show that both biochars meet the requirements of SNI 06-3730-1995 for application to soil.

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