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EVALUATING ASH CONTENT IN BIOCHAR MADE FROM SUGARCANE BAGASSE POWDER

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Abstract – *Ash in biochar from the sugarcane bagasse (SCB) powder has been researched into many practical applications, contributing to limiting environmental pollution. This article used the slow pyrolysis method at 450°C and 500°C to create biochar from the sugarcane bagasse and was based on ASTM D 2866-89 Standard to determine the ash content in this biochar. The results showed that the total ash (TA) content ranged from 4% to 8%, depending on the slow pyrolysis process.*

Keywords: ash content, biochar, biomass, slow pyrolysis, sugarcane bagasse (SCB).

I. INTRODUCTION

Biomass is an organic raw material, derived from industrial plants, and agricultural waste (such as sugarcane bagasse (SCB), sawdust, straw.) [1]. For many years, biomass has been studied for its ability to be converted into high-value bioenergy products such as biofuel and biochar [2]. To contribute to reducing the biomass waste source, converting this biomass into biochar is a necessary solution with low investment costs and environmental protection [3]. In particular, the SCB is one of the sources of waste from many various fields of agricultural and industrial production, leaving millions of tons of biomass in the environment each year. After separating the sugar water, the SCB has a moisture content of about 45±50% and contains 30±50% cellulose, 13±39% hemicellulose, and 11±27% lignin [4]. The previous solution: this SCB (considered a biofuel) was burned in the electricity generation process and produced ash as a byproduct. After that, this ash is primarily buried, which affects the surrounding environment. However, to minimize the harmful effects of this ash on the environment, many studies have highlighted some applications of the ash from biochar made from the SCB: replacing part of cement in concrete production with the following characteristics such as fine particle size, high glass content, and relatively stable chemical composition [5–7], replacing sand in creating mortar for road surface improvement [8], helping increase the durability of steel reinforced concrete beams [9]. On that basis, to have high-quality ash from biochar made from the SCB, the highly effective biochar production process using the slow pyrolysis method has been proposed [10]. The slow pyrolysis method is the process of heating biomass at a minimum temperature of 400°C, in the absence of oxygen. The biochar product from this pyrolysis process is about 30–35% by weight [11].

This article evaluates the ash content of biochar from the SCB powder, to supplement the criteria for this problem which have not been mentioned or tested in the publications of Ahmed et al. [12], Behera et al. [13], Vimal et al. [14], Jia et al. [15] . In this study, the slow pyrolysis of the SCB was performed at 450°C and 500°C to produce biochar.

II. MATERIAL AND METHODS

The SCB material is mainly from some stores that sell ultra-clean sugarcane juice in Thu Duc City, Ho Chi Minh City, Vietnam.

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The slow pyrolysis of the SCB produces biochar and the determination of the ash content of this biochar is performed in the Material Testing Laboratory at Ho Chi Minh City University of Technology and Education (HCMUTE).

The size of the biochar after the slow pyrolysis is Φ40 mm × 20 mm.

Figure 1 describes some equipment and tools mainly used for experiments.

The general process of the slow pyrolysis of the SCB to create biochar and determine the ash content of this biochar consists of 10 following steps.

Step 1: Cut the SCB into pieces according to size 30÷50 mm (Figure 2).

Step 2: Blend the SCB after cutting (Figure 3).

Step 3: Dry at 105^{o}C.

Step 4: Blend after drying.

Step 5: Sift to get the SCB powder (Figure 4).

Step 6: Weigh 23÷24 grams of the SCB.

Step 7: Pour the SCB into the pyrolysis box, press, and close tightly.

Step 8: Slow pyrolysis heating (T), holding time (τ), and cooling in the air (Table 1)

where τ_s is the time after removal from the oven until the lid of the pyrolysis box is opened.

Step 9: Remove the lid of the pyrolysis box and take out the biochar (Figure 4).

Step 10: Determine the ash content:

- Pour biochar into the ceramic cup and close the lid.

- Heat this ceramic cup at 650^{o}C, for 3÷16 hours, until the biochar becomes completely ash, and the mass does not change.

- According to ASTM D 2866-89 Standard [16], total ash (TA) is determined according to the Equation (1):

$$TA(\%) = \frac{M_a - M_c}{M_b - M_c} \times 100\% \qquad (1)$$

where M_a is the mass of the ceramic cup and the ash, M_b is the mass of the ceramic cup and the biochar, and M_c is the mass of the ceramic cup (Mc is uneven after the production process).

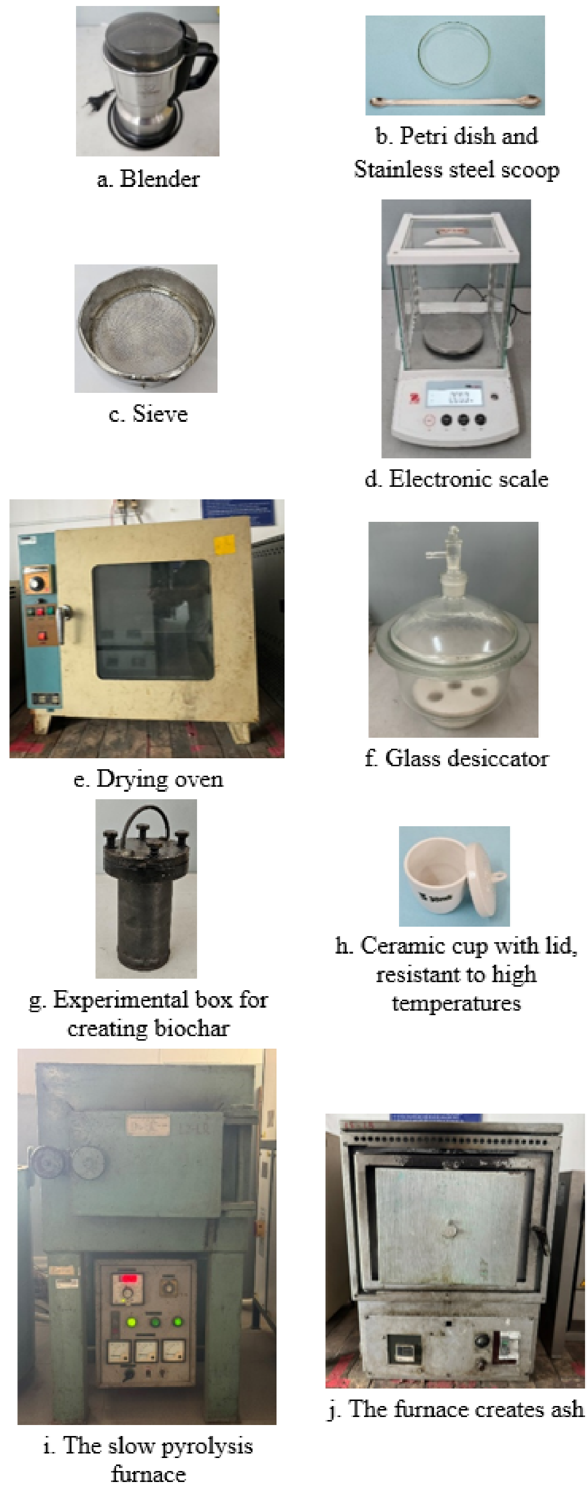

Fig. 1: Images of equipment and tools used for experiments

Fig. 2: The SCB after cutting

Fig. 3: The SCB after blending

III. RESULTS AND DISCUSSION

Figure 5 shows biochar pellets from the SCB after the slow pyrolysis process.

In this study, the biochar from the SCB burns almost completely and creates eye-catching white ash (Figure 6).

The results of TA content in the biochar from

Fig. 4: The SCB powder after drying, blending, and sifting

Table 1: Parameters of slow pyrolysis process to create biochar from the SCB

Parameters / Biochar samples	T (°C)	τ (mins)	τ_s (hours)
A	450	25	1.5
B	450	25	Cooling at room temperature
C	500	20	1.5
D	500	20	Cooling at room temperature
E	500	60	1.5
F	500	60	Cooling at room temperature

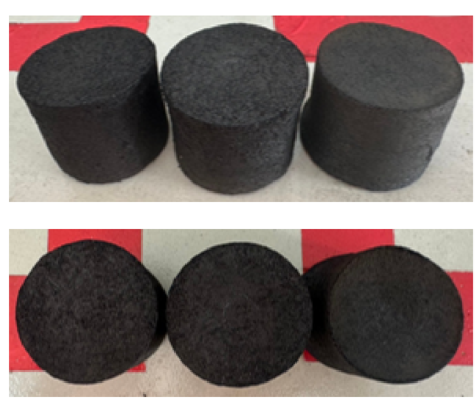

Fig. 5: The biochar from the SCB after the slow pyrolysis process

Fig. 6: The biochar from the SCB after the slow pyrolysis process

the SCB are presented in Table 2 and shown in Figure 7.

The results in Table 2 and Figure 7 show that the average ash content in the biochar from the SCB of the samples with time τ_s = 1.5 hours (A, C, and E samples) is better than those cooled to room temperature (B, D, and F samples).

In this study, the average ash content of the C biochar sample is the lowest and relatively suitable according to ASTM D 2866-89 [16].

IV. CONCLUSION

This article presents the determination of ash content in the biochar from the SCB powder. The biochar from the SCB is produced by the slow pyrolysis process at 450^{o}C with holding time (τ) 25 minutes and at 500^{o}C for 20 and 60 minutes, and cooling in air. Then heat this biochar at 650^{o}C, for 3÷16 hours, until it becomes completely ash and the mass does not change. The result shows that the average ash content of the biochar sample after the slow pyrolysis process with T = 500^{o}C, τ = 20 mins, and τ_s = 1.5 hours reaches 4% and is guaranteed according to ASTM D 2866-89 [16].

Assessing the ash content also provides a basis for determining the carbon content in the biochar from SCB.

Table 1: Parameters of slow pyrolysis process to create biochar from the SCB

Parameters / Biochar samples	M_b (grams)	M_a (grams)	TA (%)	TA_{AVE} (%)
A	28.710	28.371	4.50	5.13
	31.177	30.404	4.44	
	31.379	30.435	6.44	
B	32.546	32.209	6.12	5.72
	32.977	32.216	4.39	
	33.195	32.253	6.64	
C	**31.029**	**30.683**	**4.68**	**4.00**
	29.313	**28.532**	**3.93**	
	29.507	**28.538**	**3.38**	
D	29.359	28.410	5.38	5.74
	29.166	28.397	5.52	
	30.731	30.390	6.31	
E	29.490	28.717	6.72	6.95
	29.678	28.745	6.88	
	29.037	28.705	7.26	
F	31.476	30.720	7.01	7.95
	31.667	30.749	8.83	
	28.863	28.530	8.01	

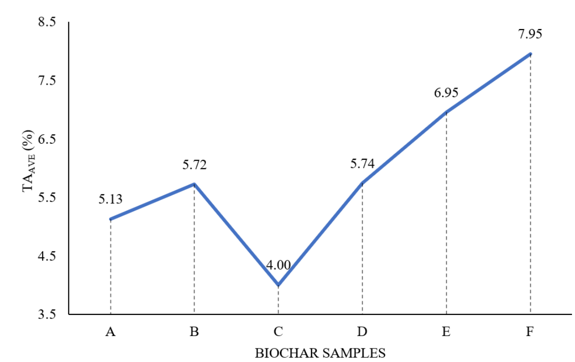

Fig. 7: The TA_{AVE} results in biochar samples from the SCB

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