Open Science and Technology
Vol. 02 No. 02, (198-202)
ISSN (Print) :2776-169X
ISSN (Online) :2776-1681

Elemental Content of Coffee Waste Biochar under Different Temperatures of Pyrolysis

Kandungan Unsur Biochar Limbah Kopi pada Suhu Pirolisis yang Berbeda

Ali Rahmat[1*], Abdul Mutolib[2], Sukamto[3]

[1]National Research and Innovation Agency, Indonesia
[2]Siliwangi University
[3]Hokkaido University

*email: alirahmat911@gmail.com

Submitted:14 March 2023 Accepted: 25 March 2023 Published: 2 April 2023

ABSTRACT

One abundant waste in the coffee shop industry is coffee powder or bean waste due to the expired. To control the coffee waste can be convert to be biochar which is useful for soil amendment. The purpose of this study was to determine the chemical properties of biochar derived from Coffee Waste. Producing biochar was done by burning the Coffee Waste using a furnace with a temperature of 250°C and 350°C, then ground and sieved with a size of 355 micrometers carried out at the Research Center for Limnology and Water Resources. Chemical property analysis using X-Ray Fluorescence Spectrometer (XRF) at Lampung Advanced Characterization Laboratory-BRIN. Based on the results of the analysis using XRF showed that the highest content in terms of the macronutrient of biochar is Potassium (K_2O) around 83%, then Phosphor (P_2O_5) around 5%, and Sulfur (SO_3) around 2-3%, then Magnesium (MgO) around 1.2-1.3%. That content only represents proportion of element, further analysis is needed to measure the concentration.

Keywords: *Biochar, Element content, Coffee waste, Temperature of pyrolysis.*

ABSTRAK

Salah satu limbah yang melimpah di industri kedai kopi adalah limbah bubuk atau biji kopi akibat kadaluwarsa. Untuk mengendalikan limbah kopi dapat dikonversi menjadi biochar yang berguna untuk pembenah tanah. Tujuan dari penelitian ini adalah untuk mengetahui sifat kimia biochar yang berasal dari Limbah Kopi. Pembuatan biochar dilakukan dengan cara membakar Limbah Kopi menggunakan tanur dengan suhu 250°C dan 350°C, kemudian digiling dan diayak dengan ukuran 355 mikrometer yang dilakukan di Puslit Limnologi dan Sumber Daya Air. Analisis sifat kimia menggunakan X-Ray Fluorescence Spectrometer (XRF) di Lampung Advanced Characterization Laboratory-BRIN. Berdasarkan hasil analisis menggunakan XRF menunjukkan bahwa kandungan makronutrien tertinggi dari biochar adalah Kalium (K2O) sekitar 83%, kemudian Fosfor (P2O5) sekitar 5%, dan Belerang (SO3) sekitar 2-3%, kemudian Magnesium (MgO) sekitar 1,2-1,3%. Kandungan tersebut hanya mewakili proporsi unsur, analisis lebih lanjut diperlukan untuk mengukur konsentrasinya.

Kata kunci: Biochar, Kandungan unsur, Limbah kopi, Suhu pirolisis.

INTRODUCTION

Coffee waste production has increased dramatically in recent years. The residue left after extracting the coffee solution from the coffee beans is called coffee waste. As coffee consumption rises, so does coffee waste. Coffee production reached 9542 tons in 2018 and is still growing (ICO, 2019). As coffee production grows, techniques for reusing coffee waste must be researched.

The spent coffee ground (SCG) is a waste from the coffee industry that is a residue produced during the brewing process. One ton of green coffee can generate approximately 650 kg of SCG as waste (Mussatto et al., 2011). It is a type of lignocellulosic biomass that contains cellulose, hemicellulose, and lignin, as well as other proteins and minerals. After use, the coffee ground is a non-toxic waste product that is either landfilled or incinerated, which is an expensive process for the coffee industry. As a result, converting this low-cost, spent coffee ground into value-added products is an urgent need. Coffee waste is used in various ways, one of them being biochar through the Pyrolysis process.

Pyrolysis, a thermal process, is a complex process in which lignocellulosic matter is converted into liquid products (bio-oil), gaseous products (pyrogas), and solid products (biochar) in the absence of oxygen (Atabani et al., 2019; Dhyani & Bhaskar, 2018; Soares et al., 2019). Pyrolysis yields are affected by the conditions and technology used and the composition of the biomass (lignocellulosic and inorganic content). This study aimed to investigate the effect of differences in pyrolysis temperature on the chemical content of biochar from coffee waste. The chemical content can be used as information whether the coffee waste biochar has the potential as a soil enhancer and a fertilizer substitution.

MATERIAL AND METHODS

This research was conducted at the Research Center for Limnology and Water Resources in Cibinong, Bogor regency, West Java, from June-July 2022. Samples of coffee waste were obtained from the Research Center for Limnology and Water Resources office, which had expired. Biochar is made by burning coffee waste in a furnace at a temperature of 250 °C and 350 °C for 4 hours (Rahmat, 2021; Rahmat et al., (2022), then ground and sieved to a size of 350 micrometers. X-Ray Fluorescence Spectrometer (XRF) analysis using the Omnian ED-XRF Panalytical Epsilon 3 XLE at the Lampung Advanced Characterization Laboratory-BRIN. Data were analyzed descriptively by comparing the chemical content of biochar burned at temperatures of 250 and 350 degrees Celsius.

RESULT AND DISCUSSION

Pyrolysis produces biochar, oil, and gas, all of which can be used as fuels (Ioannidou & Zabaniotou, 2007) Pyrolytic biochar has the potential to be used as a low-cost sorbent (Ioannidou & Zabaniotou, 2007) or as a soil amendment to improve soil fertility and carbon sequestration (Lehmann et al., 2006; Steiner 2007) According to research on tropical soils, charcoal amendments can increase and sustain soil fertility (Steiner, 2007). The beneficial effects appear to be linked to changes in soil physical, chemical, and biological properties, such as decreased acidity (SNI, 2004).

Open Science and Technology
Vol. 02 No. 02, (198-202)
ISSN (Print) :2776-169X
ISSN (Online) :2776-1681

Fig. 1. Raw material (left), biochar after pyrolysis/ burning (middle), biochar after sieved (right)

The X-ray Fluorescence (XRF) method was used to determine biochar's chemical properties from coffee waste. The characterization process was carried out on 2 samples of treated coffee waste. Differently, the first sample (Coffee250) used a pyrolysis temperature of 250 °C, while the second sample (Coffee350) used a pyrolysis temperature of 350 °C. The following is a test table for each sample.

Table 1. X-ray Fluorescence (XRF) results of the sample

No	Element (Oxides)	Coffee Waste Biochar Burn under 350°C	Coffee Waste Biochar Burn under 250°C	Unit
1	K_2O	83,411	83,717	%
2	P_2O_5	5,577	5,618	%
3	Fe_2O_3	5,150	4,305	%
4	SO_3	2,263	3,033	%
5	MgO	1,357	1,226	%
6	SiO_2	0,771	0,556	%
7	MnO	0,458	0,482	%
8	TiO_2	0,343	0,231	%
9	Rb_2O	0,277	0,333	%
10	CuO	0,146	0,169	%
11	SnO_2	0.0941	0,135	%
12	ZnO	0.0833	0.0785	%
13	SrO	0.0436	0.0434	%

From Figure 1, it can be seen the changing of the color of the sample from raw material and then after burning. This research chose low-temperature pyrolysis because it will produce a high biochar yield. However, whether pyrolysis temperature will strongly influence the element content is still questionable.

Table 1 shows that the dominant elements in biochar burned at a temperature of 250°C and 350°C are K_2O, P_2O_5, Fe_2O_3, SO_3 and MgO. The K_2O compound has the highest value, 83.411%, at a combustion temperature of 350°C, while at a temperature of 250°C, it has a content of 83.717%. There is an no increasing significantly in the element content of K_2O compounds when the temperature increases from 250°C to 350°C. This also happened to P_2O_5 and MgO compounds which no increase in compound when the temperature increases. The P_2O_5 compound burned at 250°C had a compound content of

5,618% and 5,577% at 350°C. The MgO compound burned at 250°C had a compound content of 1,226% and increased to 1,357% at 350°C, however this increasing can be neglected. The Fe2O3 compound burned at 250°C had a compound content of 4.305% and increase to 5.150% at 350°C.

The increase and decrease in nutrients with higher pyrolysis temperatures were caused by the level of carbonization and volatilization of the biochar raw material. Every material will give a different response to pyrolysis temperatures.

Furthermore, Biochar from coffee waste contains several macronutrients, however the real concentration of each element needed to be anlysis. Moreover, the existance element that categoriez as macronutrient, its possible that biochar have potential for soil amendment to improve soil quality.

CONCLUSION

Biochar from coffee waste dominantly contains K_2O, P_2O_2, SO_3, MgO which is belong to macronutrients. That information make biochar firm coffee waste can be use as soil amendment, however real concentration of each element needed to be anlysis.

ACKNOWLEDGEMENTS

The authors acknowledge the facilities, scientific and technical support from Advanced Characterization Laboratories Lampung, National Research and Innovation Agency through E- Layanan Sains, Badan Riset dan Inovasi Nasional.

DAFTAR PUSTAKA

Atabani, A. E., Al-Muhtaseb, A. H., Kumar, G., Saratale, G. D., Aslam, M. & Khan, H. A…. Mahmoud, E. (2019). Valorization of spent coffee grounds into biofuels and value-added products: pathway towards integrated bio-refinery. *Fuel 254*, 115640. https:// doi.org/10.1016/j.fuel.2019.115640.

Dhyani V, & Bhaskar T. A. (2018). Comprehensive review on the pyrolysis of lignocellulosic biomass. *Renew Energy*, 129:695e716. https://doi.org/10.1016/j.renene.2017.04.035.

ICO (International Coffee Organization). (2019). *World Coffee Consumption*.

Ioannidou, O., & Zabaniotou, A. (2007). Agricultural residues as precursors for activated carbon production, A review *Renewable and sustainable energy reviews, 11*(9), 1966-2005.

Lehmann, J., J. Gaunt, & M. Rondon. (2006). Bio-char sequestration in terrestrial ecosystems: A review. Mit. Adapt. Strat. Global Change, *11*(2), 403-427.

Mussatto, S. I., Machado, E. M. S., Martins, S. & Teixeira, J. A. (2011). Production, Composition, and Application of Coffee and Its Industrial Residues. *Food Bioprocess Technology, 4* (5), 661.

Rahmat, A. (2021). Chemical Properties of Biochar from Date Palm Seed (Phoenix dactylifera L.) under Low Temperature Pyrolysis as Soil Amendment Candidate. *Applied Research in Science and Technology*, *1*(2), 116–120. https://doi.org/10.33292/areste.v1i2.13

Rahmat, A., Ramadhani, W. S., Nur, M., Sutiharni, & Mutolib, A. (2022). Chemical Properties of Salacca Seed Biochar Under Low Temperature of Pyrolysis. *Applied Research in Science and Technology*, *2*(1), 43–46. https://doi.org/10.33292/areste.v2i1.24

SNI (Standart Nasional Indonesia). (2004) 19-7030-2004 Spesifikasi kompos dari sampah organik domestik.

Soares D.A. P, Rego F, Fonseca F, Casquilho M, Rosa F, & Rodrigues A. (2019). Catalyzed pyrolysis of SRC poplar biomass. Alkaline carbonates and zeolites catalysts. *Energy, 183*, 1114- 1122. https://doi.org/10.1016/j.energy.2019.07.009

Steiner, C. (2007). Slash and char as alternative to slash and burn: Soil charcoal amendments maintain soil fertility and establish a carbon sink. [Dissertation]. Bayreuth, Germany, University of Bayreuth, Faculty of Biology, Chemistry and Geosciences.