

Simple Biochar Production Generated From Cattle Dung and Coconut Shell

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ABSTRACT

Biochar has been widely accepted as a prospective soil amendment. Simple biochar generated from dry cattle dung (15% H₂O) was produced using simple stove made of brick (70 cm wide, 120 cm length and 40 cm high) in which 2 drums as containers for feedstock's being combusted using sawdust as fuel. Heating temperature for this process was fluctuated in between 200 to 330°C. The production of coconut shell biochar (CSB) was done under different method, which was by autothermal-combusting of feedstock's in pit (1 m depth, 1.0 m wide and 1.5 m length) (temperature was fluctuated in between 190 to 280°C). Biochar yield was 70 % and 65.82% (mass/mass) from cattle dung and coconut shell respectively. Biochar produced from coconut shell (CSB) had higher C, typically less ash and containing smaller nutrients compared to cattle dung biochar (CDB). The CSB had pH 9.9, EC 1.75 (dS/m), ash (7.36%), C (80.59%), N (0.34%), P (0.10%), K (0.84%), Ca (0.04%), Na (0.12%), Mg (0.06%) and CEC 11.78 cmol kg⁻¹ while the Cattle dung-biochar (CDB) had pH 8.9, EC 1.77 (dS/m), ash (75.34%), C (23.53%), N (0.73%), P (0.57%), K (0.69%), Ca (0.51%), Na (0.15%), Mg (0.44%) and CEC 16.79 cmol kg⁻¹.

KEY WORDS: Biochar, farm yard manure, organic carbon, soil amendment.

1. INTRODUCTION

Biochar has widely been accepted as a potential alternative which currently being suggested to overcome soil infertility problems (1, 2, 3). Biochar is a carbon-rich product obtained when organic biomass is heated under limited or without oxygen conditions (2). Soil application of biochar may enhance soil quality and it can be an effective means of helping to mitigate global climate change through C sequestration (4), which offers opportunities for sustainable soil management. The benefits of biochar application to soil rely on high affinity of nutrients to biochar and appear to be more stable and have been observed to remain in soil for hundreds or even thousands of years (5). In addition, biochar is highly absorbent and therefore increases the soils ability to retain water, nutrients and agricultural chemicals, preventing water contamination. It also contains most of the nutrients that were in the biomass, can release them slowly and is a liming agent (6). Hence, these properties can be used effectively to address some of the most urgent environmental problems including soil degradation and food water pollution from agro-chemicals and climate change (6). A lot of studies have shown that biochar could improve nutrient retention and cation exchange capacity (7, 8), decreasing soil acidity (8, 9), improved soil structure (1, 8), and increase crop yield (1, 3).

The type of organic matter or feedstock and the conditions under which a biochar is produced greatly affect its relative quality as a soil amendment (10). Biochars can be produced from wide a range of feedstocks such as animal manure, coconut shell, rice husk, and other crops waste. Biochars from plant materials are often low in nutrient content, particularly N (1). Animal wastes are generally higher nutrient content than plant wastes (11), therefore, biochar produced from animal origins may have contribution to increase soil nutrient availability. For small farmers the only problems for producing biochar is the equipment and technology. Biochar can be produced by a very simple technique such as a traditionally char making. However, the quality of biochar is unpredictable. Therefore, any effort to obtain a simple production method which yields a good quality biochar would be helpful.

In Lombok, and the other eastern part of Indonesia, there are potential organic sources to create biochar from coconut shell and cattle dung. The potential number of coconut shell per year generated from coconut plantation in such region is about 56,180 ton and 2, 830, 256 ton per year of cattle dung generated from 707, 564 animals (12). The use of these residues might be ecologically promising for improving soil quality as well as crop productivity in dryland farming system in West Nusa Tenggara Province. This paper will address simple

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biochar production from local residues of coconut shell and cattle dung in Lombok, Eastern Indonesia and their properties for soil amendment purposes.

2. MATERIALS AND METHODS

Feedstocks preparation and Biochar Production

Cattle Dung Biochars (CDB)

The cattle dung from the typical Bali-Cattle was prepared as feedstock for charring collected from collective-cattle farm in Gunung Sari District, West Lombok, Indonesia. The dung was naturally sun-dried for 6-7 days on concrete floor with plastic sheet (depending on initial moisture content) on concrete floor). As the moisture reached 15% after drying, the bulky dung was broken by hand to meet size of 4 – 5 cm while it was separated from other materials (i.e. small stones, plastics, grass, branch etc) before putting into the heating-drum. This was done in order to get uniform heating during combustion. The drum for heating materials has 56 cm in diameters and 42 cm high. There were two drums used for one running of combusting on the simple man-made stove from brick. The size of stove was 70 cm wide, 120 cm long and 40 cm height (Fig. 1). The two drums were filled with each of 10 kg dried-dung, sealed and subsequently combusting was started using saw-wood fuel and coconut fibers. Heating temperature recorded within drums increased gradually in particular during the first 2 hours and it was fluctuated in between 200 to 330 °C (average of 254oC). Steam was produced and when a lid is placed on the cylinder, the back pressure of steam slows down combustion in the hearth. It is important to push down and mixed the hot material periodically to maximize charring. Biochar yield can be harvested after 8-10 hours indicated by smoky black color chars. The chars were get off from burning stove and it was remain settle down for cooling the yield for 24 hours by initially spraying water thoroughly over surface of drum. The yield of Cattle Dung Biochar (CDB) produced with this simple method was $\pm 70\%$.



Figure 1. Simple biochar production made from Cattle Dung

Coconut Shell Biochar (CSB)

The biochar was produced from coconut shell-residues collected from coconut plantation in Tanjung, North Lombok. The simple production of biochar was conducted through an auto thermal- combusting in pit of 1.0 m deep, 1.0 m wide and 1.5 m length. Combusting was conducted for 8 hours and heating temperature was actually fluctuated in between 190 to 280°C (average of 240°C). Charring occurs as the whole treated materials changed to be black color-chars. Subsequently, banana stems and leaves were layered (10 cm thick) on the surface of the bulky chars in pit while spraying water were also treated to allow cooling for one night (12 hours). Biochar yield from charring of coconut shell with this procedure was 74.80 %. Subsequently, the yield of biochar was collected, dried and crushed to pass through a 1.00 mm sieve to create suitable field application.

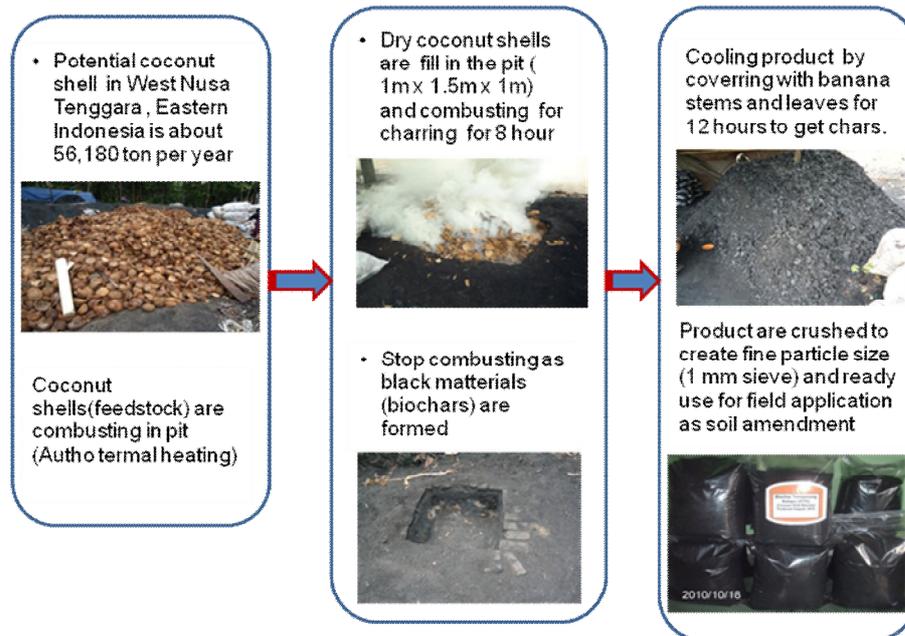


Figure 2. Simple Production of biochar from Coconuts shell

Laboratory Measurements

To characterize biochars, the following laboratory analysis and calculation (water content, bulk density, pH, EC, ash, C-organic, N, P, K, Ca, Na, Mg and CEC) were performed. Water content was determined according to gravimetric method. Bulk density was calculated from weight of biochar at 15°C which cover a vacancy of 10 cm³ (13). To measure the pH and EC, the suspension of biochar (1:1) was prepared by diluting the biochar with de-ionized water. Then the suspension was heated to about 90°C and stirred for 20 minutes to allow the dissolution of the soluble biochar components. The suspension was then cooled to room temperature, after which the pH was measured with a pH-meter (Jenway 3305) and EC was measured with EC-meter. Ash content was determined according to Novak et al (14) with dry combustion using muffle furnace at 700°C for 6 hours. Total C was determined using the method described in ASTM D 3176 (15). Total P was read with a spectrophotometer and K, Ca, Mg, and Na were measured using AAS. Fourier transformation infrared (FTIR) absorbance spectra were recorded on a Shimadzu Model 5020 FTIR Spectrometer at wave numbers from 400 to 4,000 cm. This analysis was used for comparing qualitatively vibrating absorption spectra of chars or relative intensities for the respective bands.

3. RESULTS AND DISCUSSION

Biochar characteristics

The properties of biochars produced from cattle dung and coconut shell are shown in Figure 3 show that biochar made from cattle dung (CDB) had less alkaline (pH 8.9) compared to that of biochar produced from coconut shell (CSB) (pH of 9.9). In addition, biochar made from cattle dung (CDB) had higher nutrients particularly N, P, Ca and Mg as well as containing more ash (75.34%) but lower content of C- organic (23.53%) compared to the CSB. Cattle dung biochar had a CEC of 16.79 cmol kg⁻¹ that was higher than that of coconut shell biochar with CEC of 11.78 cmol kg⁻¹. The different properties of those biochars seem to be associated with the nature of the chemical constituents in the feedstock biomass. Previous authors (Brown et al. 2006; Chan and Xu, 2009; Hammes et al. (16) have confirmed that the different nature of biochars product are typically influenced by wide range factors including different types of materials being used or feedstock quality and also different charring condition Chan et al. (1) showed that biochar made from manure will have a higher nutrient content than biochar made from wood materials. High nutrients as performed in the CDB represent the nutrition that was removed when the fodder-biomass was fed into the animals.

FTIR Analysis

The infra red spectrum of the Cattle dung biochar and coconut shell biochar are shown in Fig 4 and 5. Band assignments as summarized in Table 1, show that the two type of biochars contain heterogen functional groups and structures. Data of wave numbers reveal that most abundant chemical bonds are C-C; C-H; C=O and also containing aromatic C=C. As the surface of biochar contains heterogenic functional groups (17) containing oxygen and hydrogen (2), its interaction to soil will undergo hydrolysis and oxidation. IOxidation of biochar particle surface creates negatively charged mainly from carboxylate and phenolate groups. The higher negatively

charge of biochar surface will contribute to increase of soil CEC (7), therefore biochar would have ability to increase soil nutrient retention. In addition, biochar particles in soils could interact with mineral surfaces as well as with organic matters in soil to form organo-mineral complexes which cause biochar more stable for long-term.

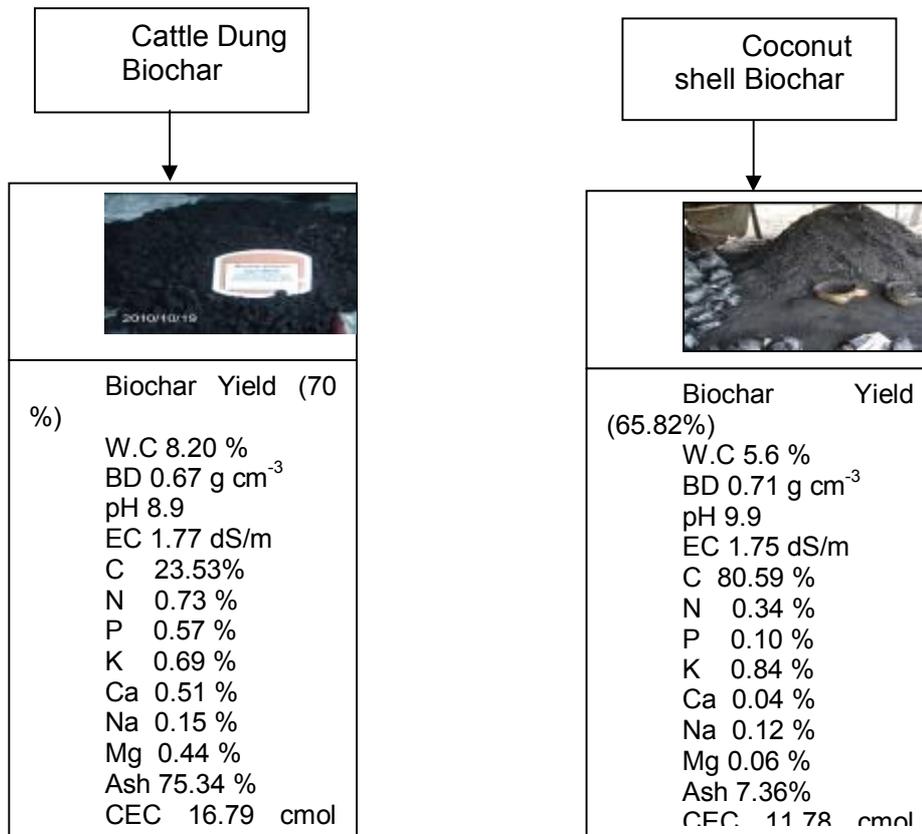


Figure 3. Biochar properties from cattle dung (CDB) and coconut shell (CSB)

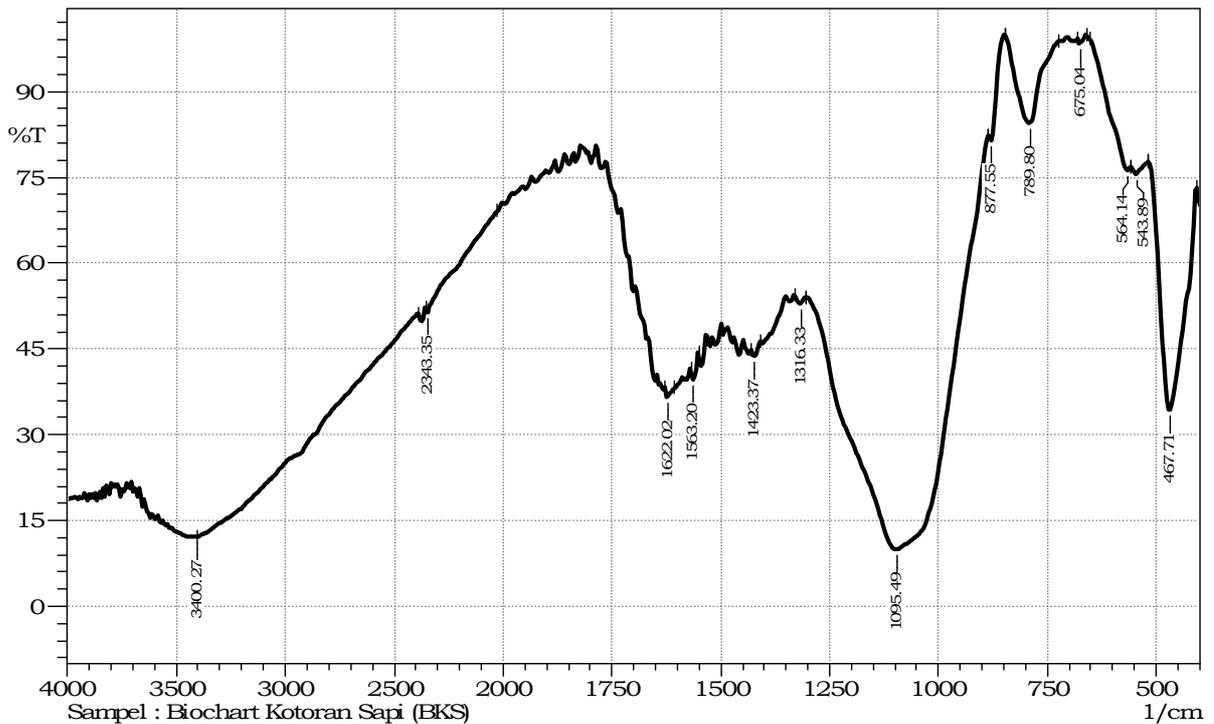


Figure 4. FTIR spectra of Char produced from Cattle Dung (CDB)

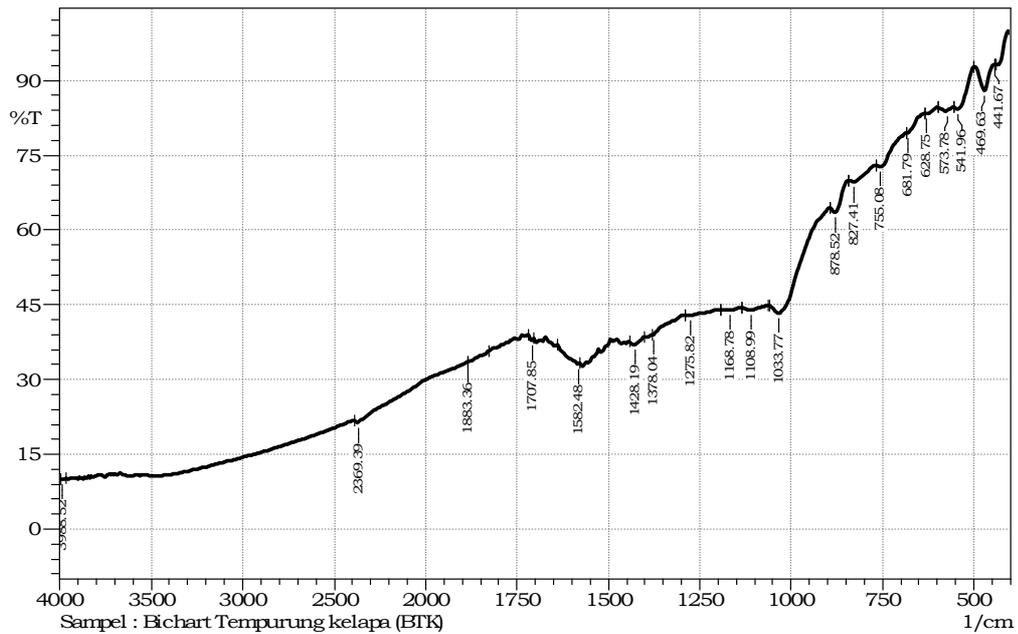


Figure 5. FTIR spectra of Char produced from Coconut Shell (CSB)

Table 1 Main functional groups of the compounds in the Cattle Dung-Biochar and Coconut Shell Biochar

| | Wave numbers (cm ⁻¹) | Infrared absorption (chemical bond) ^{*)} |
|------------------------------|----------------------------------|---|
| Cattle dung Biochar | 675.04 -877.55 | C=C-H (Aromatic-H) |
| | 1095.49 | C-O |
| | 1316.33 | C-H |
| | 1423.37 | C-H |
| | 1563.2-1622.02 | C=C; C=N |
| | 2343.35 | C-C |
| Coconut Shell Biochar | 3400.27 | O-H |
| | 573.78-878.52 | C=C-H (Aromatic -H) |
| | 1033.77-1108.99 | C-O |
| | 1378.04-1428.19 | C-H |
| | 1582.48 | C=C; C=N (Aromatic structures) |
| | 1707.85-1883.36 | C=O |
| | 2369.39 | C-C |

^{*)} Silverstein (18)

4. CONCLUSION

Simple production of biochars from cattle dung in a simple combusting brick-stove and an autotremal combusting of coconut shell in pit yielded biochar almost 70 %. (mass/mass). Those materials are potentially valuable for producing biochar for soil amendment. The carbon content of the coconut shell biochar (CSB) was higher than that of the cattle dung biochar (CDB). However, the CSB contained less mineral nutrients and CEC compared to the CDB. FTIR analysis showed that biochars contain a number of atomic grouping or chemical bonds including C-H; C-C ; C-H; C=C, C-O, C=O and -H. As the biochar contain high C with the aromatic structures, its application for soil amendment could have positive effect on improving stability of soil carbon.

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