Characteristics of Weed Biomass-derived Biochar and Their Effect on Properties of Beehive Briquettes

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ABSTRACT

Charcoal is a carbonaceous solid with a fixed carbon content of 70% or more. Among its diversified utilization techniques, biochar and briquette production have been identified as most environment friendly. It can be derived from any ligno-cellulosic biomass by pyrolysis or retorting in presence of little or no oxygen. As wastes of wood and agricultural industries have many uses, sources of charcoal or biochar production have been limited to other biomass. In North-East India, weed biomass can bea potential source of biochar with a productivity of 20 t ha^{-1} annually. Experiments were conducted to assess the yield and quality of biochar from two weed biomass:*Lantana camera*, *Chromolaenaodorata* and compared with biocharderived from pine wood. Further, propertiesof beehive briquette produced from these biocharswere evaluated. Charring was carried out in a portable metallic kiln to keep the process simple, quick and low cost. Biochar production efficiency of *Lantana* and *Chromolaena*was 27.72 and 18.34%, respectively whereas that of pine wood was 34.28%. Carbon content of *Lantana* (65.99%) and *Chromolaena*(61.22%) biochar was lesser than the pine wood biochar (75.82%). The calorific value of beehive briquettes ranged between 18.1 and 19.4 MJ kg^{-1}. The average burning time varied from 133 to 143 minutes with a peak temperature range of 437°C to 572°C. It was found that though the quality of biochar produced from *Lantana* and *Chromolaena* was inferior compared to pine wood, they can be effectively used as potential source of biochar and may be used in making beehive briquette to fulfil the energy need of rural household.

Keywords: Biochar, Beehive briquette, Weed biomass, Charring

INTRODUCTION

In the context of changing climatic scenario, attention has to be given to the potential for storing the significant amounts of carbon (C) in soil, forests and other ecosystems which certainly might be an efficient alternative means of offsetting the effect of emissions of green house gases (GHGs) and carbon dioxide (CO_2) in the atmosphere (Lehmann 2007). In this context, biochar, a pyrolysis product of plant biomass containing more than 70% carbon offers a significant, multidimensional opportunity to transform large scale agricultural waste from a financial and environmental liability to valuable assets. Biochar, fine grained charcoal added to soils, has been promoted with claims it can sequester carbon in soils for “hundreds to thousands of years”, improve soil fertility and hence increase crop yields and also provide renewable energy from pyrolysis production. Interestingly biochar incorporation in soil would yield more stable soil carbon than burning or direct land application of biomass (Baldock and Smernik 2002).

In biochar, approximately 50% of the C in biomass is left as stable residue and another 50% is released immediately, while non-burnt biomass decomposes slowly over time and leaves only 10-20% C in agricultural soil after 5-10 years (Lehmann et al. 2006). It is believed that biochar can store carbon in soil for hundreds to thousands of years and reduce the level of green house gases like CO_2 and methane significantly in the atmosphere thus offsetting the effect of climate change (Lal 2009). Biomass conversion to biochar and biofuel by pyrolysis technology has attracted a number of research activities and it has been

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considered as a viable technology to mitigate the energy demand, green house gas emission and soil carbon sequestration (Steiner 2008).

Biochar could be used as an energy carrier to meet the energy demand of rural people. In many developing countries, the charcoal produced from woody biomass is directly used in industry. On the other hand the biochar produced from fibrous or light density biomass need to be strengthened by adding binder in a briquetting machine.Charcoal briquettes can be used as fuel in rural houses for cooking, laundering and in boilers in teashops and bigger sized stoves in small hotels(Sugumaran and Seshadri 2010).Cooking tests conducted using a non-pressurized cooker (Sarai cooker, ARTI) shows that 200-250g of briquettes is enough to cook food in about 45-60 minutes with stable heat for 2 hours. Low density charcoal briquettes like beehive briquettes, produced from charcoal and mud, can be burnt smokeless for 3 hours (Mandal et al. 2012)

Biochar has been produced from different crop residues and their effects on soil properties and crop productivity have been studied by earlier researchers (Major et al. 2010; Yao et al. 2011; Peng et al. 2011) but little information is available for conversion of weed biomass to biochar. In NE India, weed biomass productivity of 20 t ha^{-1} has been observed. Hence, in this study an attempt has been made to find out properties of biochar from common weed biomass such as *Lantana camera* and *Chromolaena odorata* and characteristics of beehive briquettes made from this biochar. These weeds are abundant and naturally grown and survive in widely ranged climatic conditions and elevations. Their stems are non-thorny and becomes up to 15 cm thick as they grow older. Among many uses of these weeds, fuel wood supplement is the major one (Sankaran 2012; Francis 2000).

MATERIALS AND METHODS

Making of biochar

Three biomass namely, *Lantana camera*, *Chromolaenaodorata* and pine wood were collected from nearby forest area of the ICAR Research Complex for NEH Region, Umiam and shredded to pieces of less than 15 cm. Shredded pieces were sun–dried for two months before charring.Charring of all the biomass was carried out in a charring drum similar to one described by Nienhuys(2003).

The drum was placed on three bricks and the conical grate with chimney attachment placed inside. An entire load of chopped biomass was stacked next to the drum.The drum was filled around the funnel base with a loose layer of easily burnable material and ignited. After the first portion of biomass material started to burn, another layer of biomass material was added, covering the burning layer.The chimney extension was then placed on top of the inner chimney.More biomass was placed onto the fire, avoiding that the fire extinguishes. The white smoke escaped through the chimney.The entire drum was gradually filled with the biomass, leaving sufficient space for smoke to escape. When the smoke started turning from white (containing water) to light grey and blue, the additional chimney pipe was removed and the lid was placed on the drum. The gutter was filled with water.The fire slowly extinguished inside the drum and the biomass was charred in about two hours. The drum was cooled down for few hours before taking out the biochar.

Making of briquettes

Beehive briquettes were made using finely powdered biochar sieved through 5 mm sieve and mud as binder. In addition to binding, mud also acted as a burning controller. It reduces the rate of burning. After mixing charcoal and mudin 2:1 ratio v/v, 250 ml of water was added to make the paste soft enough to hold the structure. A mould with overall dimension of 400 × 100mm was used to make the briquettes. The mould consisted of three parts: a) cylinder, b) base plate fitted with 21 rods and c) cover plate. Cylinder's diameter was 145mm and height 85mm. Base plate had total 21 rods of 12mm diameter and 95 mm height welded on it. Cover plate had same number of holes having diameter little higher than that of rods so that it could move through the rods on base plate. After putting cover plate and cylinder on base plate, the biochar and mud dough was put into the cylinder and the whole unit was beaten on ground to increase compaction of the material. Then the cylinder and cover plate were pulled out of the base plate along with the newly formed briquette. It was placed upside down on ground and the cover plate was pressed to release the briquette. Thus, the dimension of each briquette was 145mm in diameter and 85mm in height which perfectly fits in a briquette stove. Raw briquettes were allowed to dry in open air as well as in sunlight for two weeks (Mandal et al. 2012).

Proximate analysis

Proximate analysis of biochar and briquettes was carried out following the process described by McLaughlin (2010) for characterization of biochar. Approximately 15g of sample was kept at the temp of the 150°C for 48 hours to determine the moisture content. For determination of volatile matter content 10g of sample was kept in covered crucible and put inside a Muffle Furnace at the temperature of 400°C for 30 minutes. To determine the ash content, the sample was put inside a Muffle Furnace at a temp of 550°C of 30 minutes. Residual carbon content was calculated by subtracting the amount of moisture, ash and volatile matter from the total weight. Calorific value was determined using a bomb calorimeter operating under standard conditions. About 1g sample was used for each experiment and was replicated three times (ASTM D-4809).

Combustion test

A test platform was fabricated using mild steel flats and wire mesh to carry out the combustion test. A single briquette was placed on the centre of the steel wire mesh. The platform with briquette was placed on an electronic digital balance with least count of 0.1g to record the weight loss in every two minute interval over the burning period. Each briquette was ignited by placing it over an electric heater for 5 min and allowed to burn until the temperature becomes less than 100°C. Smoke of burning was extracted using the extraction hood method (Ballard and Jawurek 1999). Temperature was recorded in every two minutes by a digital temperature indicator connected with a K–type thermocouple placed 50 mm above the base of the fire. Height of a cooking pan over an oven does not exceed this height. The temperature indicator had an accuracy of 1°C.

RESULTS AND DISCUSSION

Biochar production efficiency

Biochar conversion efficiency of the portable kiln for three biomassesis presented in Table 1. Charring efficiency ranged between 18.34 and 34.28%. The highest charring efficiency was observed for pine wood which was due to the lower moisture content. In a conventional kiln, the moisture content of the feed strongly affects the reaction time and charcoal yield. More feed must be burnt to dry the remainder (prior to carbonization) when the feed is very wet. Moisture contents of 15–20% are satisfactory for most wood kilns, which often require drying of the wood feed for 6–18 months (Antal and Gronli 2003). The lower biochar yield was observed in case of *Chromolaena* which might be due to the higher initial moisture content and leafy nature of biomass which burnt immediately.

Table 1: Biochar conversion efficiency of different biomass

Biomass	Biomass moisture content (wb, %)	Char moisture content (wb, %)	Charring efficiency (%)
Lantana camera	21.36	5.44	27.72
Chromolaena odorata	21.73	5.22	18.34
Pine wood	20.60	6.59	34.28

Characteristics of biochar

Properties of the biochar derived from three biomasses are depicted through Fig. 1. Biochar from all three biomasses had almost equal moisture content. Volatile matter was the highest in *Chromolaena* biochar (30.49 %) and the lowest in pine wood biochar (14.98 %). Ash was the highest in *Lantana*biochar (12.41 %) and the lowest in *Chromolaena*biochar (8.29 %). Carbon content of pine wood biochar (75.82 %) was the highest followed by *Lantana* (65.99 %) and *Chromolaena*

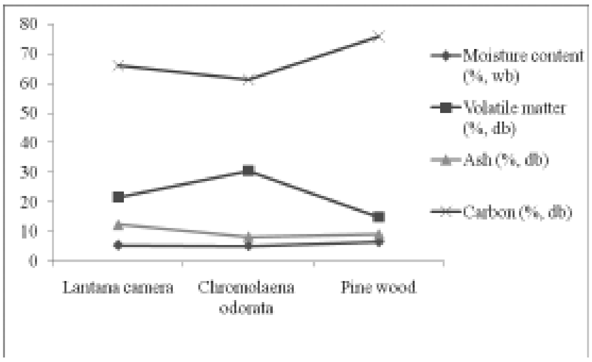

Fig. 1: Properties of biocharmade from three biomasses

biochar (61.22 %). Both the weed biomass had higher carbon content than the biochars derived from digested and undigested sugar beettrailings but lesser than wood biochar (Major et al. 2010; Yao et al. 2011).

Characteristics of briquettes

Average temperature profiles of briquettes made from three types of biochar are shown in Fig. 2. Good combustion temperatures in the degassing phase and slow rate of temperature decline in the carbonization phaseof burningis ideal forcooking and heating purposes (Smit and Meincken 2012). Beehive briquette of *Lantana* biochar showed comparable temperature with pine wood biochar briquette in degassing phase. The highest temperature attained by *Lantana* and *Chromolaena* biochar briquette was recorded as 553°C and 437°C which was lesser than pine wood biochar briquette by 19 and 135 °C, respectively.

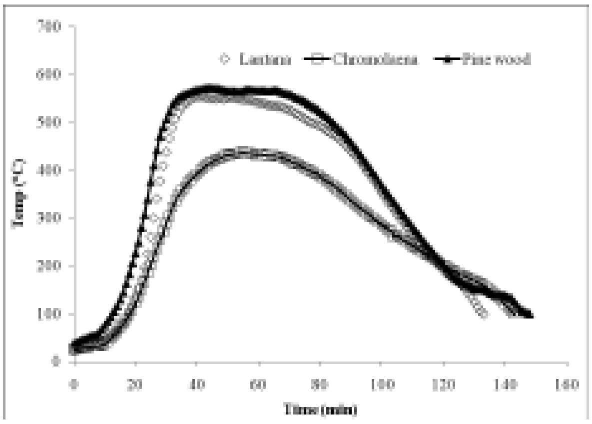

Fig. 2: Temperature profile of briquettes made from three biochars

Duration of burning of *Lantana* biochar briquette was 133 min, which was 10 min lesser than the pine wood biochar briquette and 4 min lesser than *Chromolaena* biochar briquette. It shows that all briquettes burn for almost 2.5 hours which is sufficient time for cooking three items in everyday meal. Calorific value of briquette made from Lantana and Chromolaenabiocharwas 18.6 and 18.1 MJ kg -1 which was lesser than that of pine wood biochar briquette by 0.8 and 1.3 MJ kg -1, respectively.

CONCLUSIONS

Biochar produced from two weed biomasses: *Lantana camera* and *Chromolaena odorata* in a portable metallic kiln had similar characteristics with biocharproduced from pine wood. The conversion efficiency of biomass of *Lantana* and *Chromolaena* into biochar was 27.72 and 18.34%, respectively whereas that of pine wood was 34.28%. Carbon content in biochar obtained from *Lantana* (65.99%) and *Chromolaena* (61.22%) was lesser than the pine wood biochar (75.82%). The beehive briquettes made from these three biochars recorded average burning time from 133 to 143 minutes with a peak temperature range of 437°C to 572°C. The highest burning time and temperature was recorded in case of pine wood biochar briquettes. The calorific value of beehive briquettes made from *Lantana* and *Chromolaena* biochar was comparable with pine wood biochar briquettes.

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