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CHARCOAL PRODUCTION FROM DISCARDED TENDER COCONUT SHELLS – AN EFFECTIVE WAY OF RECYCLING.

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ABSTRACT Tender coconut water is a natural drink which has high demand worldwide, particularly in tropical countries like India. However, in many places the tender coconuts shells (TCSs) are simply discarded which create a nuisance in terms of mosquito breeding centre and waste management problem. A study has been conducted to recycle them into charcoal and its effectiveness as a fuel. A total of 25 kg raw shells were collected and dried for carbonization for 3 days. The results revealed that the charcoal yield was 38.2 % of the dry weight of the TCSs. The moisture content of the charcoal was found to be 8.2%, ash content 4.2%, volatile matter content 24.7%, fixed carbon content 62.8%; all these fit the normal standard of good charcoal. The conversion of discarded tender coconut shells into charcoal has found to be helpful for effective municipal solid waste management and also useful economic point of view for empowering poor people.

KEYWORDS : Charcoal, Income, Kiln Method, Tender Coconut Shells, Waste management

Introduction

Charcoal is a solid lightweight and black residue produced from animal and vegetation when substance is burned in a confined space with limited air at a high temperature. It is a cleaner, easier and less smoky and smelly than other biomass fuels (Tara, 1998). There are some reports on charcoal production from wood (Nisgoski *et al.,* 2014; Straka, 2014; Msuya, 2011; Nakorn, 2010), and agricultural wastes (Manoj, 2015; Sumaran and Seshadri, 2009).

Coconut (*Cocos nucifera*) is an important and useful perennial agricultural product grown throughout the year compared to other fruits (Koteswararao *et al.,* 2016), and is found in over 70 countries worldwide. There is a high consumer demand for tender coconut water as a natural drink in many parts of the world, particularly in tropical country like India. However, disposal of tender coconut shells in their selling places create a major environmental problem since the opened shells serve as the breeding centre for mosquitoes which act as disease vectors. Further, its mix up with other wastes create nuisance in solid waste management. The unwanted tender coconut shells can be a good a source of fuel by recycling into charcoal. Taken into consideration of solving an environmental issue and fulfilling the high demand for energy, we have conducted a study converting tender coconut shells into charcoal to be used as a fuel.

Methods and Materials

Collection of raw materials

The tender coconut shells were collected from in and around Mangalagangothri campus, which were disposed selling shops. A total of 25.0 Kg was collected. The tender coconut shells were divided into small pieces, each piece of the weight ~250 g. The pieces were dried in sunlight for days prior to charcoal production process.

Charcoal Production

Processing and converting dried tender coconut shells into charcoals were done by Kiln method (Ghosh, 2015). In short, a circular pit was dug of the size 30Cm depth and 70Cm of diameter. The constructions begin by stacking small branches of the eucalyptus collected in the garden to help in burning, followed by place a large stick of 60Cm in the side to the center of the Kiln and pack the materials (tender coconut shells) around it until the Kiln is full in form of the curvature. Carefully the stick was removed and leaving a hollow space (door) in the side that goes to the center of the Kiln which allows the insertion of the small branch of eucalyptus for ignition. To start carbonization, a piece of branch is dropped to the small branch through the door and lighting the fire; when the fire is well underway from the bottom going up and radially from the center to the side, the Kiln is covered by the leaves followed by the soil to avoid the entry of oxygen for producing charcoal under incomplete combustion reaction. After 72 hours, the charcoals were harvested from the pits and packed in the plastic bin for further investigation. Physical parameters such as density and yield among others were determined. Charcoal density was calculated using Archimedes' principle (Prakash and Ajit, 2014).

Proximate Analysis

Five (5) charcoal pieces were chosen randomly from the harvested charcoals and crashed into powder for further analysis. The 6mg of powder was taken in the laboratory and analysed for moisture content (%), volatile organic matter, fixed carbon, and ash content using the SDT Q600 V20.9 Build 20 instrument. According to Raphael and Zuwena, (2015) and Ijagbemi et al., (2014), the proximate analysis of the charcoals was done using the following formula.

$$MC(\%) = \frac{mass\ of\ air\ dry\ samples\ -\ mass\ of\ sample\ after\ drying\ at\ 105°C}{mass\ of\ air\ dry\ samples} \times 100$$

$$VOM\ (\%) = \frac{mass\ of\ samples\ at\ 150°C\ -\ mass\ of\ samples\ at\ 550°C}{mass\ of\ samples\ at\ 150°C} \times 100$$

$$Ash\ content\ (\%) = \frac{mass\ of\ residue\ (mass\ of\ sample\ at\ 850\ °\ C)}{mass\ of\ sample\ at\ 150°C} \times 100$$

$$Fixed\ Carbon = 100 - (AC + VOM)$$

Results and Discussion

The results in table 1 and 2 shown the physical characteristics and quality of tender coconut shell charcoals based on the production process.

Table 1: Physical characteristics/ nature of charcoal produced from TCSs

Parameters	C_1	C_2	C_3	C_4	C_5	Average± SD
Carbonization in hours	72	72	72	72	72	72±0
Dry material	225	228	216	240	220	225.8±9.18
Charcoal produced in gr	87.3	87.55	83.8	90.24	82.76	86.33±3.04
Charcoal density	0.31	0.286	0.264	0.317	0.29	0.29±0.02
Charcoal yield in %	38.8	38.4	38.8	37.6	37.6	38.24±0.61

In nature, the color of charcoal produced is uniformly black and C_1, C_2, C_3, C_4, C_5 represent charcoal samples selected randomly for analysis. It was found that the average density is 0.291g/Cm^3, this is may be attributed to the raw material used in terms of seize and concentration, sources (soil), maturity and hardness. The finding of Madakson *et al.,* (2012) shown that the density of the coconut shell was 2.05g/Cm^3.

The charcoal production average calculated was 86.33g from 225.8g/piece of dried raw material and the yield determined was found to be 38.2%. The yield of charcoal was influenced by some factors like raw material, weather, and climate, carbonization condition, among others (Kwon *et al.,* 2009) and vary in the range of 25-30% of the dry weight of shells (Salman, 2016; CDB, 2017);

Table 2: Results of the proximate analysis showing the quality of charcoal

Characteristics	C1	C2	C3	C4	C5	Average± SD
Moisture content in %	8.2	8.25	8.15	8.32	8.1	8.20±0.08
Volatile Organic Matter in%	23.8	25.4	24.7	25.2	24.6	24.74±0.6
Fixed Carbon Content %	63.8	62.1	62.9	62.16	63.08	62.8±0.5
Ash content in %	4.2	4.25	4.25	4.32	4.22	4.25±0.04
Ash Dry	4.57	4.63	4.62	4.71	4.59	4.62±0.05
Fixed Carbon Dry	69.51	67.69	68.49	67.79	68.65	68.43±0.73
Volatile Dry	25.92	27.68	26.89	27.5	26.76	26.95±0.69

The results revealed that the moisture, volatile matter, fixed carbon and ash content for TCSCs produced were 8.2%, 24.74%, 62.8% and 4.62% respectively, which are in the range of a good charcoal quality. Several researches have been conducted on charcoal application; it was found that charcoals should present volatile matter contents of 20–25% for steel use (Santos, 2008). The quality analysis of charcoal produced by Botrel *et al.,* (2007) shown 25.50% of volatile matter, 74.25% of fixed carbon, and 0.25% of ash. The work done by Neves *et al.,* (2011)shown that the average levels of volatiles, fixed carbon, and ash were18.92, 80.29, and 0.80% respectively.

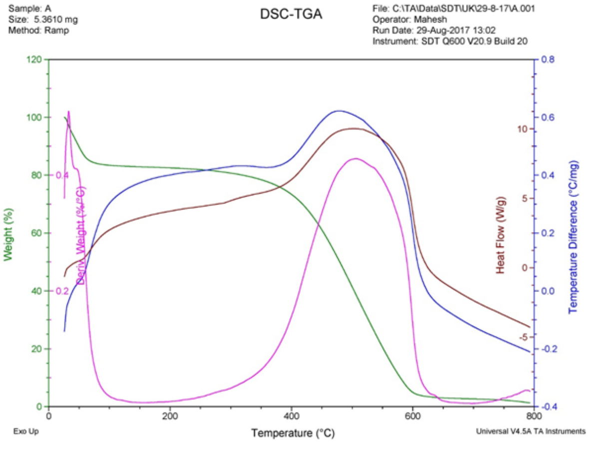

Fig 2: Heat flow of charcoal produced

The tender coconut shells charcoal have advantages in terms of greater heat intensity, cleanliness and convenience in use. Based on analysed samples, the charcoals with lower ash content value has invariably higher heating values and the one of higher ash content has least heating value. The high moisture content also influences the low value of the calorific values (Mizero et al., 2014). The presence of high mineral matter in substance material cause high ash content and contributes to the reduction of charcoal heating value (Mizero et al., 2014; Tsoumis, 1991).

Conclusion

The charcoals generated from tender coconut shells by the Kiln method were found to be very effective strategy for recycling. The moisture, volatile organic matter, ash content and fixed carbon values of that charcoal produced are in range of normal biofuel. On the environmental front, the TCSCs production could be encouraged to reduce the huge volume of coconut waste disposed in and around the environment and to reduce deforestation for the purpose of charcoal production.

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