

# Development of Wood Charcoal Making Kiln Suitable for the Rural Poor of Bangladesh

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## Abstract

This study was carried out to construct a low cost wood charcoal making kiln by using an empty oil drum. The performance of this kiln was examined using three types of wood which are abundantly available in Bangladesh. These were: Mango wood, Rain tree wood and physicnut wood. During the experimentation data on duration of burning, yield of charcoal, ash production and weight loss were recorded using the standard methods. Yield of the kiln was calculated using the standard formula. The yield of the kiln was 28.80 percent (by weight) using mango wood with an initial moisture content of 24.76 percent. The yield of the kiln varied with duration of burning time and also with the types of wood used. Physicnut produced about 25.11 percent charcoal when the moisture content of the wood was 36.27 percent. Similarly the efficiency of the kiln using Rain tree wood was 28.57 percent when the moisture content was 27.67 percent. This kiln is simple in construction and it can be constructed using locally available materials by the local artisan. A single person can operate this kiln easily. The construction cost also was very low (about Tk. 1300 = US\$ 19). The poor people of the rural area in Bangladesh can easily use the drum kiln for producing charcoal.

**Key words :** Wood, Charcoal and Kiln

## 1. Introduction

Sixty percent of all wood taken from the forests is believed to be burnt as fuel either directly or by first converting it into charcoal. The proportion of fuelwood used to make charcoal can only be estimated but it is probable that the amount is around 400 million cubic meters per year throughout the world (FAO, 1983; Gill, 2007; Robert, 1982).

Energy is the most important key factor for the living standard of the rural people of Bangladesh. Presently the rural people are suffering much due to the increase of fuel price such as kerosene which is used for lighting at night and also some villagers use it for cooking with the stove. Besides, most of the rural people directly burns wood for cooking which is not environmentally friendly due to production of smoke containing mostly CO and CO<sub>2</sub> and also the efficiency of the burning is less. This phenomenon requires large volume of extra wood which could be saved by using wood charcoal.

The demand for wood charcoal in Bangladesh is increasing day by day in the small scale manufacturing workshops, such as agricultural machinery shop, for making machine parts. The annual consumption of charcoal has been

increased from 279 metric tons in 1997 to 298 metric tons in 2005 (BBS, 2007).

Charcoal is light, black, porous material resembling coal, with about 85 percent carbon. It is produced by heating biomass under a system of controlled supply of air. This results in the removal of water and other volatile constituents (e.g. hydrogen, methane and tars). Principal raw materials are medium to dense hardwoods such as beech, birch, hard maple, hickory, and oak. Others are softwoods (primarily long leaf and slash pine), nutshells, fruit pits, vegetable wastes; paper mill residues, sugarcane waste; rice husk and bamboo are commonly used for making charcoal. Better grades of charcoal come from raw materials with low sulfur content.

When wood is converted to charcoal, over half of the energy value is lost. It is preferred because it is lighter and less bulky, making it easier to transport. Charcoal can be stored indefinitely, whereas wood is attacked by insects and fungi that reduce its energy value. And charcoal is a more concentrated heat source and produces less smoke than wood. A less obvious reason is that carbonization of wood is an easy way to break down large pieces to a size easy to use for cooking (FAO, 1983).

In developing countries charcoal is mainly used as domestic fuel for cooking and heating but it is also

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an important industrial fuel. Large amounts are used in foundries and forges, in the extraction and refining of metals, especially iron, and in numerous other metallurgical industries as well as in cement factories and chemical applications. Also, in those countries with abundant forest resources the export of charcoal can be a profitable industry. Now a days carbon tablets are available for the treatment of ulceration, ultra sonogram for the detection of cancer, pain in the stomach etc.

In most developing countries the traditional methods of charcoal making are the only technology known, but due to shortages and rising prices of raw materials in industrialized countries, new and improved technologies for charcoal production have been developed and taken into use during the last decades. Through technical achievements, the carbonization of almost any type of forest, wood industry or agricultural residues has become feasible and also higher energy yields can be obtained by producing commercially valuable by-products.

Based on the above discussions the objective of this study was to develop a simple and low cost wood charcoal making kiln and to evaluate its performance.

## 2. Materials and Methods

### 2.1 Kiln design

An empty oil drum of 55 gallon capacity was used to construct the kiln for making charcoal. The drum was the main body of the kiln. In order to facilitate loading and unloading  $\frac{3}{4}$  portion of one end of the drum sheet metal was suspended by hinge (Fig.1). For smoke outlet a 6.5 cm dia hole was kept at the opposite end of the drum. The drum was placed horizontally on the surface. Finally the kiln was set on a brick structure to restrict the

movement of the kiln during burning and experimentation.

### 2.2 Raw materials

Mango wood (*Mangifera indica*), Physicnut (*Jatropha carcus*) and Raintree wood (*Samanea saman*) were used as raw materials for making charcoal. For each trial 15 kg raw wood of mango, 6 kg of physicnut wood and approximately 15 kg of raintree wood was burnt. The amount of physicnut was taken less as it was a bulky shrub.

### 2.3 Moisture content of wood

The average initial moisture contents of raw wood were 24.8%, 38.2% and 27.2% for Mango, Physicnut and Raintree wood respectively. Oven drying method was used to determine the moisture content of wood. In this method wood chips of 0.1 to 0.15 cm thick were dried in an oven at 105°C for a period of 24 hours (Anonymous, 2004).

### 2.4 Procedure of operation

**Loading the kiln:** Cross wise arrangement of wood gives slightly higher yield than length wise loading (Fig. 2 a) (Hibajene, 1994). Each sample was weighed before drum being loaded. Loading in the drum was done carefully keeping 6 to 8 cm air space underneath of the wood.

**Firing the kiln:** Firing the kiln along wind direction gives better output than firing against the wind. Firing along the wind is advantageous, with time saving to the producer and benefits in the form of improved quality charcoal (Hibajene, 1994). After loading, initiation of firing was done from the back of the kiln for better burning. When firing was initiated from the front side wood burning could not be completed due to production of dense smoke which contained CO and CO<sub>2</sub>. An oil soaked rag wrapped on a piece of wire was used for ignition of fire on to the bulk of wood. The burning time was recorded using a stopwatch.

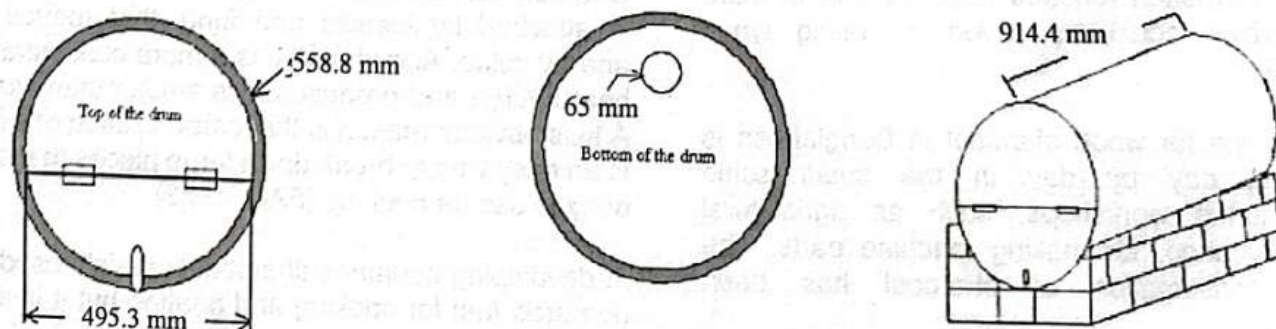


Fig. 1. Kiln design

**Sealing of kiln:** When  $\frac{2}{3}$ <sup>rd</sup> of the wood was burnt or the fire came to the front of the kiln, the inlet and outlet of the kiln were closed. To avoid air entrance into the kiln the inlet and outlet openings were sealed by mud. The rest  $\frac{1}{3}$ <sup>rd</sup> of the wood was burnt by the remaining heat inside the kiln. Then the kiln was left for cooling for few hours.

**Open air burning:** A pit of size 60x60x45 cm was constructed in an open place as shown in Fig 3. In the pit 15 kg of mango wood was burnt and it took

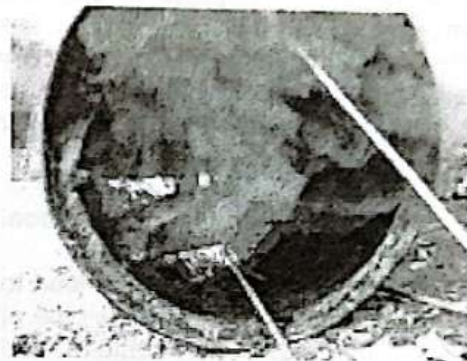
30 minutes. In the open air method a lid was used to put-off the fire completely when  $\frac{2}{3}$ <sup>rd</sup> portion of wood was burnt.

**Yield performance:** When the kiln was cooled down the charcoal was unloaded and weighed. The yield of charcoal obtained was calculated from the following equation.

$$\text{Charcoal yield (\%)} = \frac{\text{Weight of charcoal (kg)}}{\text{Weight of dry matter of wood (kg)}} \times 100 \dots (1)$$



a) Loading



b) wood burning



c) Leak proofing with mud

Fig. 2. Charcoal making process



a) Burning in progress



b) Covering by a lid

Fig. 3. Charcoal making at the open yard

### 3. Results and Discussion

The yield of charcoal from different types of woods used in the drum kiln is shown in Table 1.

The above table shows that higher efficiency of the kiln was obtained using Mango and Raintree wood while the lowest was found for Physicnut. It is probably due to the differences in the hardness of the individual wood. Wood of Physicnut is comparatively soft in comparison to those of Mango and Raintree. The charcoal obtained from Physicnut is softer in comparison to charcoal obtained from Mango and Raintree wood. The burning quality of individual wood varies greatly due to their physical properties such as compactness, bulk density, amount of dry matter and the overall structure of the wood.

#### 3.1 Effect of duration of burning on charcoal yield

The performance of the kiln is directly attributed to the yield of charcoal which depends on the type of kiln, duration of burning, heat content and temperature inside the kiln, moisture content and type of wood.

The effect of duration of burning on charcoal yield is shown in Table 1. From the Table it is evident that yield of charcoal depends directly on the duration of burning. Yields increased with the increase in burning time from 15 minutes to 45 minutes and during this period the charcoal yield increased by 18.16%, 21.26% and 17.62% for

Mango, Physicnut and Raintree respectively. After that period the yield decreased in all cases due to conversion of charcoal into ash.

#### 3.2 Effect of duration of burning on ash production

Ash content depends on the duration of burning, moisture content of wood, mineral matter, such as silica and calcium and magnesium oxides, etc. The effect of burning duration on ash production is shown in Table 1. The ash content increased with burning duration. After a certain period the ash content increased significantly which caused decrease in the total yield of charcoal. Maximum yield of charcoal associated with less amount of ash reflect on the better performance of the kiln as well as the suitability of wood type for charcoal production. The ash content of charcoal varied from about 0.5% to more than 5% depending on the species of wood, the amount of bark included with the wood. Production of good quality charcoal depends on the physical properties of wood.

#### 3.3 Comparison of performance of drum kiln with open air burning

To compare the kilns performance with open air burning some Mango wood samples were burnt outside of the drum kiln and the results are shown in Fig. 4. The duration of burning was 30 minutes. The same amount of wood for burning in the drum kiln method took 40 minutes. In the open air burning there was no control of air supply which helped to reduce the time required for burning.

Table 1. Yield of charcoal produced from Mango, Raintree and Physicnut wood

Type of wood	Sample No.	Weight of Wood (kg)	Moisture content (%)	Weight of dry matter(kg)	Burning Time (min)	Ash Content %	Unburnt wood %	Weight loss* %	Charcoal yield %
Mango	1	15	24.79	11.28	15	1.33	84.21	3.82	10.64
	2	15	26.97	10.95	30	1.83	52.03	27.88	18.26
	3	15	24.76	11.29	40	2.22	2.66	66.33	28.80
	4	15	23.05	11.54	50	3.21	0	69.93	26.86
Physicnut	1	6	38.26	3.70	15	1.61	78.95	15.59	3.85
	2	6	40.33	3.58	35	6.98	8.38	60.90	23.74
	3	6	36.27	3.82	42	9.68	0	65.21	25.11
	4	6	37.51	3.75	50	13.34	0	62.12	24.54
Rain Tree	1	16	27.2	11.65	15	1.26	85.39	2.40	10.95
	2	14	26.86	10.24	40	3.32	9.28	60.06	27.34
	3	15	27.67	10.85	45	3.69	2.77	64.98	28.57
	4	15	28.74	10.69	50	5.05	1.96	64.91	28.07

\* Weight loss due to loss of volatile matter and for conversion

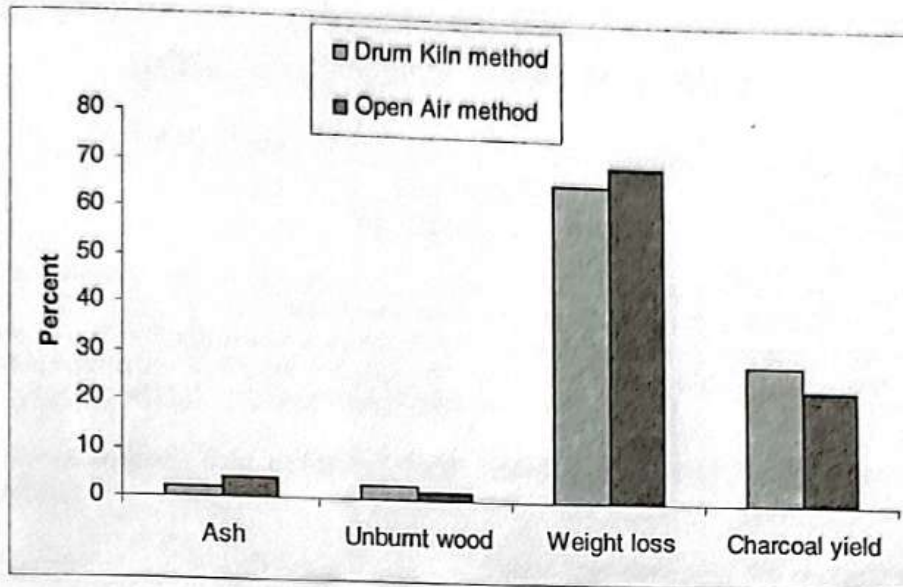


Fig. 4. Comparison of performance between the burning of drum kiln and open air burning

The figure shows that the drum kiln method produced higher percentage of charcoal yield than that of open air method. The open air method produced approximately 5 percent lower yield than the drum kiln method. Unlike the drum kiln method in open air method it was difficult to restrict the oxygen supply and this was the main reason for lowering the yield of charcoal in open air method.

#### 4 Conclusion

The use of charcoal is increasing day by day in rural, urban and peri-urban areas. To meet this increasing demand improved and low cost kiln should be designed, fabricated and made available with the users. A single drum kiln constructed for producing charcoal showed an yield of 28.80% for mango wood. The drum kiln gave maximum charcoal yield with a burning duration of 40-45 minutes. Open air method produced approximately 5 percent lower yield than the drum kiln method.

This kiln is simple in construction and it can be constructed using locally available materials by the local artisan. This kiln can be operated by a single person. The construction cost is also very low. This single drum kiln can produce charcoal about 25-28 % of the wood supplied.

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