A chain of technologies for using sugarcane trash as a household fuel

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Technologies pour l'utilisation des résidus de canne à sucre comme combustible domestique.

Annuellement environ 4,5 millions de tonnes de résidus de canne à sucre sont brûlés uniquement dans l'état de Maharashtra. ARTI a développé une série de technologies permettant la conversion des résidus en briquettes pouvant être utilisés comme combustibles domestique dans les foyers ruraux. Cette technologie procure non seulement des possibilités de revenu mais également une énergie à la fois relativement propre et facilement accessible

Introduction:

Every hectare of sugarcane harvested leaves behind about 10 tonnes of dried leaves of sugarcane, called sugarcane trash. The trash resists biodegradation, and therefore cannot be used as directly as a fertilizer. It cannot be used as fodder, as it is highly indigestible. It is a bulky and low density biomass, so it cannot be easily removed from the field, and also cannot be used directly as fuel. Chopped and/or briquetted sugarcane trash cannot be used as fuel, because it produces a lot of smoke. Also, attempts to briquette the trash have showed that it required a very high expenditure of energy to compress it. Consequently, the farmers just burn off the 'useless' trash in the field itself.

On the other hand, it is well known that organic material can be charred, the char can easily be crushed into a powder, the powder can be mixed with a binder, and briquetted into a compact solid fuel. The char briquettes are equivalent to charcoal in burning characteristics and combustion efficiency. If a properly designed stove is used, the char briquettes can be used as a relatively clean household fuel.

In the context of the sugarcane trash, several key issues needed to be considered:

- The charring process should not involve collection and transportation of sugarcane trash in large quantities over long distances.
- The charring process should be as efficient and as environment-friendly as possible.
- The charring and briquetting processes should not require too high energy inputs.
- The stove should be specifically suited to the burning characteristics of char briquettes, and yet be as user-friendly as possible.
- The special stove as well as the char briquettes should be available in the local market, at prices that are affordable to rural low-income households.

With these considerations, the Appropriate Rural Technology Institute (ARTI) developed a chain of technologies, which is described in this paper.

The charring kiln:

The design of the charring kiln is shown in Figures 1 and 2. The oven is basically a cylindrical brick and mud structure, with a grid made out of steel bars fitted near the bottom. The space below the grid is the combustion chamber. A chimney fits on top of the oven, and provides the draught for keeping the fire going in the oven. In the present version, the oven holds seven retorts (tall cylindrical cans shown in Figure 2) at a time, arranged in the manner indicated in Figure 1. In order to operate the kiln continuously, it is necessary to fabricate at least fourteen retorts. To remove and load retorts in the oven, the chimney has to be lifted up. Figure 2 shows the prototype kiln that is in operation at our field station.

Each retort holds 3 kg of trash, and yields 1 kg of char at the end of the charring run. Thus, each batch converts 21 kg of trash into 7 kg of char. An additional 10 kg of trash are consumed as fuel for firing the kiln. The first batch takes 2 hr, subsequent batches take about 40 minutes each. The kiln can be operated in two 8 hr shifts per day. An 8 hr shift comprises 7–8 batches, yielding about 50 kg of char.

The capital cost is Rs.5000 (Rs1000= US$20), for fabrication of the chimney and 14 retorts, and an additional Rs.600, for buying the 400 bricks, for the brick and mud structure. The trash collection cost can be about Rs.750 per ha, if a tractor-drawn rake is used. The labour charge is Rs.200 per day, for two labourers per shift (@ Rs.50 per labourer). Taking into account all the operating costs, the production cost turns out to be Rs. 2.40 per kg of char. If labour is provided by family members in a family-owned operation, the production cost is just Rs. 0.40 per kg.This cost analysis is based on the material, fabrication, and labour charges currently prevalent in Maharashtra.

ARTI is in the process of developing a scaled up version of the kiln, wherein the char output per shift would be doubled, further bringing down the production cost.

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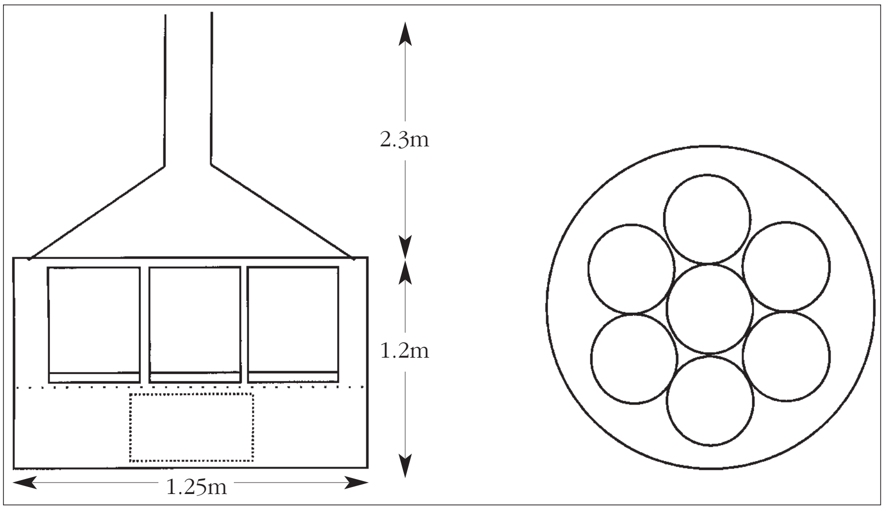

Figure 1: The charring kiln – heights are approximate (vertical and horizontal cross sections)

Figure 2: Prototype kiln at ARTI's field station in Phaltan, Maharashtra State

Figure 3: Operating the extruder

The Briquetting Process:

The char is powdered by manually running a roller over it. It is then mixed with a binder. We use a paste of waste grain as the binder. The floor debris of flour mills, available for Rs. 1.5 per kg, are used for making the binder. The paste is made by boiling the flour in water. 1 kg of the briquettable mixture contains approximately 900 gm of char, and the paste of 100 gm of waste grain. It is made into a dough by adding water. The mixture can be briquetted using any type of briquetting machine. We have used a hand operated worm screw extruder to produce cylindrical briquettes as shown in Figure 3. The machine produces about 1 kg of briquettes per hour. Taking into account the cost of char-binder mixture, and the labour cost, the cost of the briquettes is Rs.6–7 per kg. By hooking the machine on to an electric motor, the output can be increased while the high labour cost is replaced by the relatively lower cost of electricity. In this case, the production cost can be reduced to about Rs.2–3 per kg. The briquettes produced from the machine are sun dried for a couple of days.

In Maharashtra, charcoaling of wood is banned. As a result, the charcoal available in the market is either illegally produced or imported from the nearby states. As a result it is costly (about Rs.8–9 per kg) and always in short supply. Calorifically the char briquettes produced from sugarcane trash are equivalent to good fuel wood, however, they burn cleanly with higher combustion efficiency than wood. Thus, the briquettes are a legal and a cheaper option to charcoal, and a more user-friendly option to fuel wood.

Sarai Stove:

The individual components of the Sarai stove are shown in Figure 4. The fully assembled stove is shown in Figure 5.

The different components are described below.

a) Combustion chamber: It is an open ended mild steel cylinder, with an aluminium lining from inside. There is a door on the side, and a series of holes along the periphery at the bottom. The holes serve as air inlets. There are two clamps on the side near the top for holding the outer jacket.
b) Outer jacket: It is an open ended cylinder that fits on top of the combustion chamber. There are two rows of holes circumscribing the cylinder near the top, and is also equipped with a handle.
c) Fuel holder: This is a mild steel cylinder with an open top and a cast iron grate at the bottom. Solid fuel in the form of wood chips, coal, charcoal, char- or biomass briquettes, etc., is placed in the holder, which in turn is placed inside the combustion chamber through its side door.
d) Cooker with lid: The cooker is a cylindrical vessel that can be inserted into the outer jacket, leaving an annular space of just about 2.5–3 mm between the walls of the two. It has a wide rim at the top, which seals the annular space. The lid fits snugly into the open top of the cooker.

To operate the stove, the fuel holder, loaded with fuel, is inserted into the combustion chamber. The outer jacket is fitted on to the chamber, and the cooker is inserted into it. About

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Figure 4: Components of Sarai stove


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Figure 5:Sarai stove assembled

200 ml (a drinking glassful) of water is poured into the cooker, and the cooking vessels are stacked in it, one on top of the other. The cooker is closed with the lid and the fire is started.

The air required for combustion of the fuel enters from the holes at the bottom of the combustion chamber and is sucked into the fuel stack through the grate at the bottom of the fuel holder. The hot gases and flames from the fire pass through the annular space between the outer jacket and the cooker, and come out through the holes near the top of the outer jacket. The heat is conducted into the cooker through its bottom and walls, and brings the water inside to boil. The cooker fills up with steam and this generates sufficiently high temperature within the cooking vessels to cook the food items. Steam cooking has the advantage, that the substances to be cooked are never heated beyond 100 deg. C, and therefore they never get charred. Because a double jacket surrounds the vessels, the cooking process continues using the stored heat even after the fire has gone out, and the food remains warm for several hours. This hotbox effect increases the fuel use efficiency of the stove. As the lid is not airtight, the excess steam escapes from it. Thus, the stove acts as a steamer and not as a pressure cooker.

If no water is placed in the cooker, it can be used as an oven. For operations like frying, making unleavened bread, etc., the outer jacket can be detached from the combustion chamber and the chamber can be used as a portable single pot stove.

The outer jacket and the cooker can also be used with a gas or kerosene stove, to increase the fuel use efficiency.

It is also possible to operate the stove using a small electric heating coil in the place of the fuel holder.

The stove can hold four cooking vessels (about 15 cm in diameter and about 6.5 cm in height), one on top of the other, at a time. The capacity of each vessel is about 250 gm of rice, pulses, cut vegetables, etc., or 350–400 gm of potatoes, eggs, etc. Thus, if all four vessels are used, it is possible to cook enough food for a family of 4–5 persons, in about 30–35 min.

The solid fuels that can be used in Sarai are wood chips, charcoal or char briquettes. However, cutting of wood into chips is a bother for the users, and charcoal is not available readily and at affordable prices in rural markets. Thus, char briquettes, produced locally, are an ideal fuel for the Sarai stove. Just 100 gm of briquettes are enough to cook one meal for a family of 4–5 persons, if full use is made of the hotbox effect. We have found that, if properly used, the efficiency of the Sarai stove can be as high as 70% with char briquettes as the fuel.

The present cost of the Sarai stove is Rs.600. It is expected that the cost would come down a bit if the stoves are mass produced.

Conclusion:

To date, sugarcane trash, which is annually produced in huge quantities, had not been put to any use. The chain of technologies described here allows use of sugarcane trash as a household fuel. The chain involves

1. Conversion of sugarcane trash to char, by an environment-friendly, continuous batch process
2. Briquetting of the char into a solid fuel form
3. Use of an efficient, clean and user-friendly stove ideally suited for the briquettes as fuel

The techno-economic feasibility of each link has been tested. The manufacturing technologies involved in each step are easy to implement in rural areas, and therefore the chain also provides new income generating opportunities in rural areas. Attempts are now on to popularise this system in Maharashtra state.

The charring technology developed by ARTI can be used for charring or charcoaling of any type of biomass, for any purpose. The technology involves burning the combustible gas produced in the charring process and using the heat for the process itself, rather than venting or flaring the gas. Thus it has a great potential for converting wood and waste biomass into a superior fuel for household use, in an affordable, efficient and environment-friendly manner.

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