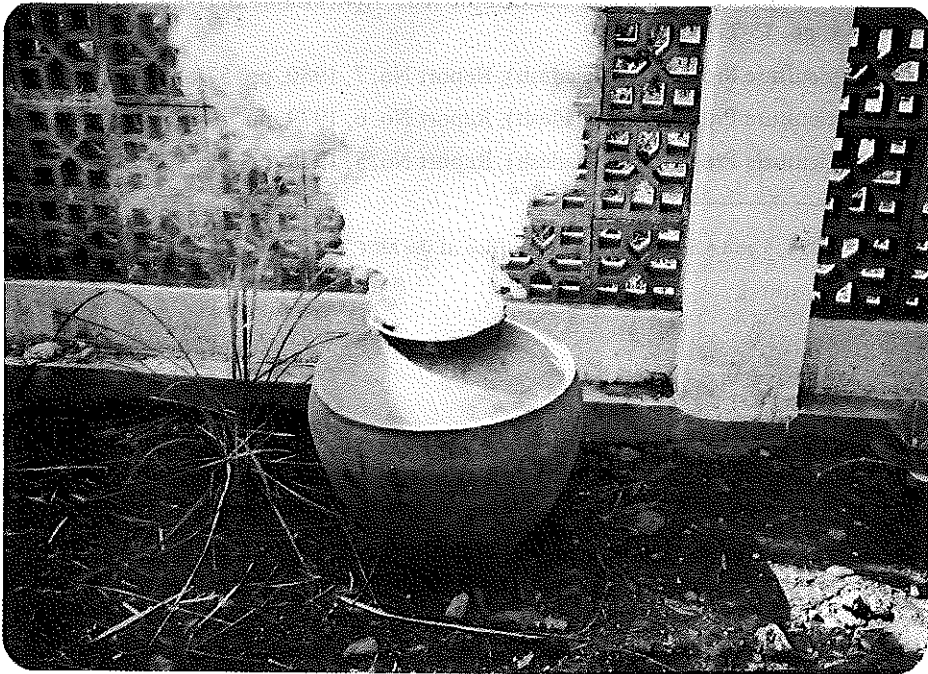


Directions for Manufacturing Biobriquets and Hybrid Stoves

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An earthen water pot costing US\$1, used as a kiln, processing dry leaves and grasses to biochar.

PROCESSING OF BIOMASS TO BIOCOAL

Biobriquets are briquets from biocoal or coal processed from biomass. They are made from dry biomass such as leaves, grasses, land- and water-weeds, and agricultural wastes.

A 10 cm layer of biomass is put into an open container used as a kiln and fired. The kiln may be a drum, a water or flower pot, a 50 x 50 x 85 cm trough built from bricks and clay mortar, or a 55 x 55 x 55 cm hole in the ground lined with stones or bricks. The mouth of the vessel may be narrowed or closed by a sheet of metal, of ceiling board, of earthen ware, or of wetted plywood.

A thick column of smoke will emerge from the mouth of the vessel, preventing air from entering the kiln, and subsequently reaching the glowing biocoal near the bottom, and burning it to ash.

Biomass is added gradually into the kiln for about an hour. Stirring the biomass with a metal or green wooden rod will cause it to burn evenly. Biomass burns in two steps: first it burns exothermally without air into coal; and secondly the coal burns exothermally with air into ash. Only the first step is allowed to proceed in the kiln.

Flaming of the biomass should be prevented by: (a) stirring it, (b) adding more biomass into the kiln, (c) narrowing the mouth of the kiln, or (d) closing the mouth for a few seconds.

When all the biomass has been converted to coal, which can be judged from the thinning of the smoke even when churned by the stirring rod, then generous amounts of water should be promptly poured on the glowing char to extinguish the fire.

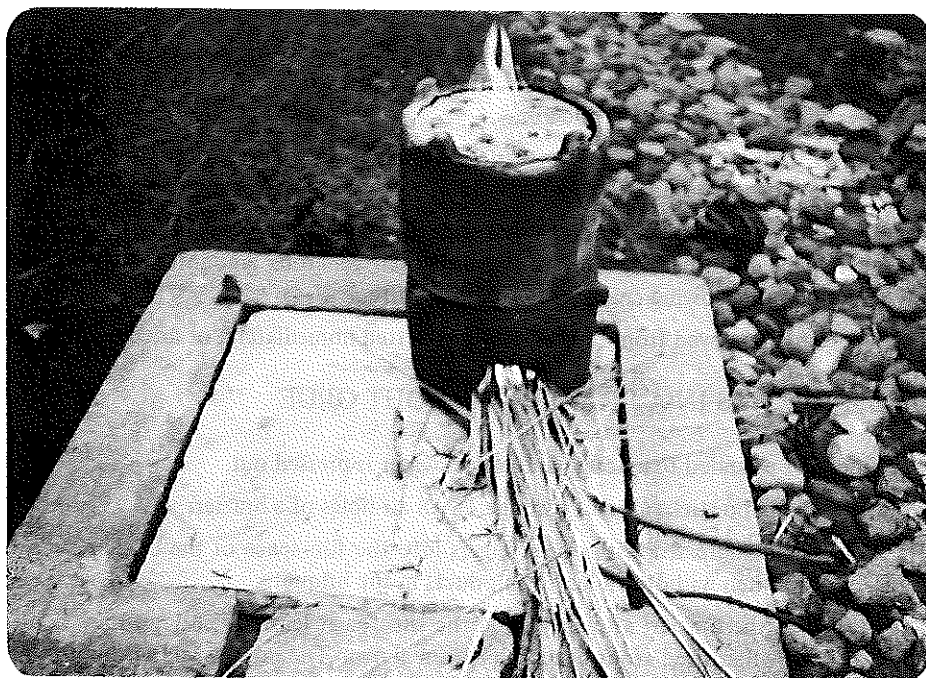
The wet char is removed from the kiln and briquetted immediately, or dried and stored.

CASTING BRIQUETS IN A BRAZIER WITHOUT GLUE

- ★ Wet biocoal is pounded to a dough and excess water is pressed out.
- ★ Wooden or bamboo sticks are put through 15-18 air holes of a brazier.
- ★ The dough is compressed with one's fingers into the fire space of the brazier between the sticks. The sticks are then withdrawn leaving air ducts in the briquet.
- ★ The briquet in the brazier, after drying in the sun for at least seven days, may be used for cooking or roasting when fired from beneath or from above. The briquet will burn in its air ducts smokelessly and odourlessly.



A biobriquet casted in a traditional earthen brazier costing US\$0.50. Burning the brazier briquet and burning biomass in the ash compartment of the brazier will convert it into a hybrid stove.



A special earthen hybrid stove costing US\$2.00 comprised of an upper brazier briquet with 17 holes and a lower wood stove.

Biocoal for the casted briquets could be saved when mixed with particulate biomass such as rice hulls, sawdust, dust from coconut husks, minute leaves of *Leucaena glauca*, *Caliandra* etc, pounded broad leaves and needles, both dry or fresh. Two volumes of wet biocoal and one volume of particulate biomass are mixed and pounded to dough, and this dough is compressed into a bio-briquet confined in a brazier. This mixed biobriquet, after drying, will also burn with practically no smoke and odour.

MOULDING LUMP BRIQUETS WITH GLUE

Glue is cooked from water and 5% tapioca flour, or flour from tubers of Ceararubber (*Manihot glaziovii*), or from stamped dried cassava. Glue could also be obtained from leaves. Leaves of hundreds of species of plants could be pounded and used as glue or binder for biobriquets – for instance the Leguminosae: *Bauhinia*, spp like *B. purpureae*; *Leucaena*, spp like *L. glauca*; *Cassia*, spp like *C. siamea* and *C. occidentalis*; *Crotalaria*, spp like *C. retusa*; *Albizzia*, spp like *A. falcata*; *Acacia*, spp like *A. auriculiformis*, *Sesbania grandiflora*, *Tamarindus indica*, etc; *Araceae*, spp like *Colocasia esculenta*, *Arisaema filiforme*; *Malvaceae*, spp like *Hibiscus rosasinensis* and *H. tiliaceus*; *Bombacaceae*, spp like *Ceiba pentandra*; *Euphorbiaceae*, spp like *Pedilanthus*; *Apocynaceae*, spp like *Plumiera acuminata* and *Allamanda cathartica*; *Asclepiadaceae*, spp like *Calotropis gigantea*. Paper wetted and pounded may also be used to glue biobriquets.

Glue from starch, green leaves, wet paper, or cement, could be pounded with wet biocoal to dough, and the dough moulded to lump briquets. The amounts of the substances needed for glue are 5% starch, 12.5% paper, or 2-5% cement.



Cooking with a tin brazier biobriquet placed on three bricks. The brazier is made from a biscuit tin with 9 holes punched in its bottom and 8 holes near its lip. Through one of these latter holes the glow of the burning briquet can be discerned.

The lump briquets could be moulded without any tools into spherical briquets by compressing the dough in the palm of the left hand using the fingers of the right hand. Alternatively cylindrical briquets could be made by compressing the dough into a tube. Moulds of different shapes could also be used.

A quarto or folio-sized piece of paper is spread in a tray filled with water, and both of its faces are rubbed to become wet through. The paper is then strewn with biocoal powder, rolled, pounded to a dough, and the dough is moulded into a lump briquet. A piece of paper that can be compressed into a sphere 2 cm in diameter should be added with enough coal powder to give a spherical biobriquet 4 cm in diameter.

Lump briquets dried in the sun for three days can be used as a substitute for charcoal.

MOULDING LUMP BRIQUETS WITHOUT GLUE

Biocoal from biomass is processed in a kiln with the mouth nearly closed. Tar will then be deposited on the char, making it difficult to be briquetted with glue, but allowing it to be moulded into lump briquets without glue, the tar functioning as a binder. A kiln with a T-shaped bamboo or iron pipe as a condenser, used for pyrolyzing biomass, will convert the biomass into pyrolygneous fluid containing acetone, tar, methanol, and acetic acid, together with tar-coated char suitable for briquetting without glue.

The biocoal thus processed, and extinguished with water, is pounded to a dough, and the dough is compressed in the hand into spherical briquets or in a tube into cylindrical briquets, 3-4 cm in diameter.

Bigger cylindrical briquets with a diameter of 14.5 cm and a height of 12 cm, having 9 canals

Table 1: Varieties of biobriquets

Char from	Admixture %	Binder %	Kind of Briquet	Colour	Strength of Briquet	Remarks	
Leaves, grasses, weeds, or vegetable wastes (30% yield)	None	None	Lump	Black	Medium	Wet char is pounded with admixture	
			Cylinder with canals				
			Contained in brazier				
	Glue from starch 5%	Lump	Black	Strong	Dry char is mixed with glue		
						Cylinder with canals	
	Cement 2.5%	Lump	Grey	Strong	Wet char is pounded with glue		
						Cylinder with canals	
	Paper 12.5%	Lump	Blackish	Medium			
						Cylinder with canals	
	Pounded green leaves from: Leguminosae, Malvaceae, Arceae, Bombacaceae, Bombaceae, Apocynaceae, Asclepiadaceae, Agave, Pedilanthus, etc. 12.5%	Lump	Black	Strong			
						Cylinder with canals	
	Rice hulls 30%	None	None	Contained in brazier	Blackish	Medium	Wet char is pounded to dough before briquetting
	Sawdust 30%						
	Pounded dry leaves 30%						
Pounded green leaves 30%							

with a diameter of 13 mm, could be cast in a standard biscuit tin of 14.5 cm diameter. The folded edge of the tin should be cut away to allow the casted briquet to be released more easily after drying and shrinking. For this purpose the inner wall of the tin may also be lined with a sheet of plastic. The canals in the briquet are formed by passing bamboo or wooden sticks through nine holes punched in the bottom of the tin and extracting them after casting. After drying in the sun for at least seven days the briquets will be dry enough to be used for cooking when burned in a standard brazier made of clay or cast iron. A cheap simple standard brazier may be made with a biscuit tin of the same dimensions as the tin for the mould. Nine holes are punched in its bottom, similar to the holes in the bottom of the mould, and eight holes are punched near the edge of its mouth allowing the heated air to escape when a pan is placed on the burning brazier.

Autumn leaves may be processed into such lump briquets to save fossil fuels.

MAKING HYBRID STOVES

A biobriquet without glue can be cast in a conventional clay brazier of the following minimum dimensions: diameter: 23 cm, overall height: 23 cm; height of ash compartment: 13 cm. These braziers, having some 17 holes in their floors and an opening of 10 x 10 cm in the wall of the ash compartments, may be bought for about US\$0.50.

The brazier biobriquet is fired by burning dry biomass on its upper surface. When a few of the canals of the biobriquet have caught fire, then all its 17 canals will eventually become incandescent with a temperature of about 700°C.

A moderate amount of wood or other biomass is burned in the ash compartment of the brazier, and the smoke ascending through the glowing canals of the biobriquet burns, producing heat and eliminating hazards to health.

A brazier thus used may be called a hybrid stove. The heat it delivers is the sum of the heat of combustion of the wood, the biobriquet, and the smoke.

A hybrid stove may also be constructed from a biscuit tin of 14.5-20 cm diameter and 9-15 cm height, and placed on top of a wood stove compiled of bricks and mud. Nine holes of 12 mm diameter should be punched in the bottoms of the tins and 12 holes of 10 mm diameter are punched near the edge of their mouths for the outlet of the combustion products, and a biobriquet is moulded into the tin. One may also construct special clay braziers with combustion and ash compartments of greater heights.