THE SUITABILITY OF EUCALYPTUS SAWMILLING AND LOGGING WASTES FOR CHARCOAL IN ZAMBIA

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ABSTRACT

The use of logging, thinning and other types of wastes from large-scale industrial plantations of Eucalyptus grandis and E. cloeziana for charcoal production is discussed. Charcoaling experiments were carried out using a portable metal kiln and a small rectangular brick kiln using Eucalyptus waste wood in the form of roundwood and slabwood. Average yields were 21.4% for the brick kiln and 19.7% for the steel kiln. The absolute yields from the steel kiln, however, were considerably lower when using slabwood than roundwood. The ash content of charcoal was very low 1-2%, volatile matter content 15-25%, carbon content 70% and bulk density 160 kg/m^3, on average. The bulk density was a little lower than that for charcoal from indigenous species (220 kg/m^3). A preliminary survey indicated that it is general acceptability to domestic users.

INTRODUCTION

In Zambia, fuelwood and charcoal production accounts for 85% of the total wood consumption. It is estimated that 75% of the total population (5.48 million in 1980) rely on energy from wood for domestic cooking and heating (Brown, 1980). Wood is preferred to other fuels because it is readily available often at minimal cost except for the collection time. Charcoal as opposed to firewood is most popular among the low- and medium-income groups in urban areas of Zambia. It has been estimated that about 88% of urban households in Zambia use fuel in the form of charcoal (Weerakoon, 1982).

Nearly all the charcoal is produced from the indigenous forest resources. Indigenous species are mixed and referred to as "indigenous charcoal". Charcoal burners are allocated coupes (6 ha of forest) by the Forest Department at a fee of K6 (K1 = 0.483 US Dollars, February 1985) per m^3 of wood extracted. Other sources of raw material for charcoal burners include tsetse fly control cutting areas (approximately 20,000 m^3 were cut in 1980), agricultural clearing areas and industrial forest plantations, which involves 3500 ha of indigenous forest being cleared every year (FAO, 1981). All charcoal in Zambia is produced by traditional earth-clamp kilns using the stack method. It is estimated that at least 435,000 t of charcoal were produced in Zambia in 1983 (Manacas, 1984). The worth of this charcoal to consumers was estimated to be K87 million.

Studies are in progress to reduce dependence on indigenous species for charcoal production and to include logging and sawmilling wastes (Musonda, 1984).

MATERIALS AND METHODS

Raw material

Charcoaling experiments were carried out to test the use of logging and sawmilling wastes in charcoal production. The species investigated were Eucalyptus grandis and E. cloeziana, either as single species or mixed together in the proportion of 1:1. The latter is referred to as "Eucalyptus charcoal". The wood density of E. grandis and E cloeziana are estimated at 470 kg/m^3 and 790 kg/m^3 (dry weight basis) respectively.

The logging wastes included first thinnings and other logs discarded at sawmilling because of either deformity or badly attacked by insects and fungi. These were cross-cut into billets of 0.5 m and 1 m lengths. The diameters of the billets ranged from 5 cm to 30 cm. For the sawmill wastes, slabwood was the main material, 2-10 cm thick and 1 m long. The moisture content varied from 15% to 37% (dry weight basis).

Kilns used

An earth kiln (commonly used throughout the country), a portable steel kiln (steel kiln) and a small rectangular brick kiln (brick kiln) were used. The latter two kilns are of Tropical Institute design.

The billets cross-cut into lengths of 0.5 m and 1 m were used in the steel kiln and brick kiln respectively. For the earth kiln 1 m lengths were used.

Earth kilns are usually built from approximately two cords (4.24 m^3) of wood covered with earth turf and slowly carbonised.

The steel kiln consists of two interlocking cylindrical sections and a conical cover. The cover is provided with four equally spaced steam release ports which may be closed off with plugs as required. The kiln is supported on eight air inlet/outlet channels, arranged radially around the base. During charring, four smoke stacks are fitted onto alternate air channels (Paddon and Harker, 1980). It has a capacity of 7 m^3 of wood.

The brick kiln consists of a brick chamber for carbonising the wood, a smoke hole and a chimney. The chamber has air vents and an entrance which is sealed with bricks as required. The kiln has an earthen floor and a roof made from mild steel sheets. The sheets are suspended from an external wooden framework to prevent them sagging during the operation of the kiln (Paddon and Robinson, 1984). The capacity of the brick kiln is 14 m^3 of wood.

Carbonisation period and yield

The carbonisation period is the time from ignition to bagging of cooled charcoal. The charcoal yield is determined from the formula:

$$\text{Percentage yield} = \frac{\text{Oven dry weight of charcoal}}{\text{Oven dry weight of charge}} \times 100$$

Physical properties

Bulk density

Charcoal was loosely packed in a wooden container of 1 m^3 capacity and the weight recorded in order to determine the bulk density of the charcoal.

Burning and hardness properties of charcoal

Burning properties were tested in a brazier using lumps of charcoal of 2.5m diameter or more. A 500 g sample of charcoal was ignited. After ten minutes the time taken to boil 200 ml of water was recorded. Fresh pots with the same volume of water were put onto the brazier until it could no longer bring the water to boiling point. The average time taken to bring water to the boil was calculated and charcoal residue was recorded.

To test the hardness of charcoal, fifteen 500g bags of charcoal pieces suffiently large to be retained on a 2.5cm x 2.5cm wire mesh were dropped from a height of 2m five times. The amount of charcoal retained was recorded as a percentage of the original 500g.

Calorific value

The procedure of the International Organisation for Standardisation (ISO) was followed.

Chemical properties

The chemical properties that were tested include the ash content, carbon content and volatile matter. Ash was analysed to determine its composition of phosphorus (P); Sulphur (S); Silica (Si) and iron (Fe). The ISO procedures were applied in determining chemical properties.

Survey on the use of Eucalyptus charcoal for domestic purposes

Questionnaires were sent to 1000 charcoal users in Kitwe as a preliminary investigation on the acceptability of Eucalyptus charcoal.

Indigenous charcoal

For comparison purposes the physical and chemical properties of charcoal made from indigenous species in traditional earth kilns were determined.

RESULTS AND DISCUSSION

Indigenous charcoal

The properties of charcoal from indigenous species are presented in Table 1.

This method of charcoal production has several advantages: the process is labour intensive; it requires no additional equipment except for hand tools, and no foreign exchange; and it is already familiar to a large number of people. But the disadvantages include: low yields (7-10% on dry weight basis); longer carbonisation periods (3-5 weeks) and little or no control on carbonisation. Studies have shown that a 10% increase in moisture content of wood or earth turf lowers charcoal yield by 2%.

Eucalyptus charcoal

Carbonisation period and yield

The carbonisation periods for the earth kiln was 14 days and for the brick and steel kilns, 3 and 6 days depending on the moisture content of the wood.

Charcoal from the earth kiln was generally contaminated with soil, roots, leaves etc., because the wood raw material is covered in tuff (sods) before lighting for carbonisation. There was greater loss due to ashing in the earth kiln than the other two, owing to little or no control of aeration during carbonisation. Thus yields in the earth kiln are the lowest. The yields of the three kilns are shown in Table 2.

Eucalyptus cloeziana had the highest percentage yield in all kilns. It is a heavier timber. Slabwood produced better results in the brick kiln than in the other two kilns while logging wastes are better utilised in the steel kiln.

The brick kiln is the most efficient kiln for both logging and sawmilling waste. But for substitution in the present system, the steel kiln is best because of its mobility. The brick kiln however would be suitable for large sawmills.

Physical properties

Eucalyptus cloeziana has the highest bulk density of 190 kg/m^3; the average for E. grandis and mixed was 160 kg/m^3. This is a little lower than charcoal from indigenous species.

The burning and hardness properties are presented in Table 3. There was little difference in these properties, and all types of charcoal produced would be suitable for domestic and industrial purposes.

The results on calorific value are presented in Table 4. There are marked differences in the heat energies (calorific values) and this may be due to differences in the rate of burning during carbonisation.

Chemical properties

The chemical properties are given in Tables 5 and 6.

The chemical properties seem to be comparable and in the range of the requirements of charcoal for industrial use, for example in copper refining. Ash composition is also quite comparable except for silica which is quite high in the case of the earth kiln because of contamination with soil.

Survey on the use of Eucalyptus charcoal for domestic purpose

The results showed that 65% of the users did not like E. grandis charcoal because it was very light and burnt too quickly. Eucalyptus cloeziana and mixed Eucalyptus charcoal were more favourably received and 70% of users felt it could be substituted for indigenous charcoal.

CONCLUSIONS

A greater part of the Zambian population will continue to use firewood and charcoal for their domestic needs for a long time to come. A potential to increase the use of charcoal in industry exists.

In order to ensure a continued supply of fuelwood in Zambia fast-growing species of Eucalyptus have to be established and the use of logging and sawmill wastes for charcoal production should be encouraged because the properties of this charcoal are as good as charcoal from indigenous species. The survey of charcoal users indicated that Eucalyptus charcoal is generally acceptable.

The present method of charcoal production (by earth clamps) will need to be replaced with more efficient methods such as portable steel kilns and brick kilns. Financial assistance to encourage charcoal burners to employ the net method must be made.

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TABLE 1: Physical and chemical properties of indigenous charcoal produced by earth kilns

Properties	Values
<u>Physical</u>	
Bulk density	220 kg/m^3
Hardness assessment	90%
Burning (boiling time)	2.00 min
Calorific value	31,350 KJ/kg
<u>Chemical</u>	
Carbon content	74%
Volatile matter	23%
Ash content	3.0%
Phosphorus	1.5%
Sulphur	0.2%
Silica	1.0%
Iron	1.2%

TABLE 2: Charcoal yields (%) from earth, steel and brick kilns

	Kiln		
Type of wood	**Earth**	**Steel**	**Brick**
Logging waste			
E. grandis	7.1	17.5	16.0
E. cloeziana	9.6	20.0	19.4
Mixed	8.5	19.7	18.4
Slabwood			
E. grandis	2.9	10.6	17.4
E. cloeziana	6.0	15.3	29.6
Mixed	4.1	13.9	21.4

TABLE 3: Burning and hardness tests

Type of wood	Kiln	Burning properties: Boiling time (min)	Burning properties: Residue Weight (g)	Burning properties: %	Hardness assessment: Weight retained (g)	Hardness assessment: %
Logging waste						
E. grandis	Earth	2.94	114	23	338	68
	Steel	2.95	118	24	367	73
	Brick	2.97	121	24	305	61
E. cloeziana	Earth	2.99	127	25	406	81
	Steel	2.90	120	24	400	80
	Brick	2.96	125	25	403	81
Mixed	Earth	2.64	118	24	366	73
	Steel	2.65	111	22	364	73
	Brick	2.67	112	22	365	73
Slabwood						
E. grandis	Earth	2.80	118	24	340	69
	Steel	2.83	122	24	370	75
	Brick	2.86	128	25	325	62
E. cloeziana	Earth	2.90	112	23	408	83
	Steel	2.93	117	24	400	84
	Brick	2.97	120	23	410	87
Mixed	Earth	2.89	118	24	407	81
	Steel	2.91	126	25	409	82
	Brick	2.93	128	26	410	82

TABLE 4: Calorific value (KJ/kg) of Eucalyptus charcoal

Type of wood	Kiln: Earth	Kiln: Steel	Kiln: Brick
Logging waste			
E. grandis	28,440	30,900	30,390
E. cloeziana	28,510	29,470	29,640
Mixed	28,480	29,750	29,900
Slabwood			
E. grandis	28,000	30,560	30,080
E. cloeziana	28,230	29,060	29,490
Mixed	28,130	29,350	29,260

TABLE 5: Chemical properties of Eucalyptus charcoal

Type of wood	Kiln	Chemical properties (%)		
		Ash	Carbon	Volatile matter
Logging waste				
E. grandis	Earth	1.9	70	21
	Steel	1.6	70	19
	Brick	1.5	72	19
E. cloeziana	Earth	1.8	71	17
	Steel	1.0	70	17
	Brick	1.0	73	15
Mixed	Earth	1.6	69	18
	Steel	1.3	70	15
	Brick	1.2	70	14
Slabwood				
E. grandis	Earth	2.9	69	27
	Steel	2.5	70	24
	Brick	2.3	71	25
E. cloeziana	Earth	1.7	68	26
	Steel	1.2	70	20
	Brick	1.0	69	18
Mixed	Earth	2.3	70	25
	Steel	1.9	70	22
	Brick	1.6	70	21

TABLE 6: Ash Composition (%)

Type of wood	Kiln	P	S	Si	Fe
Logging waste					
E. grandis	Earth	1.7	1.4	12.4	1.6
	Steel	1.5	3.9	10.6	1.3
	Brick	2.6	1.5	9.3	1.1
E. cloeziana	Earth	1.7	2.6	10.3	2.2
	Steel	3.3	2.1	7.5	1.2
	Brick	3.1	1.9	4.8	1.2
Mixed	Earth	1.7	1.9	10.4	2.0
	Steel	2.6	3.0	9.8	1.2
	Brick	2.9	1.6	8.0	1.1
Slabwood					
E. grandis	Earth	1.6	1.3	17.0	2.9
	Steel	1.5	3.7	11.3	1.4
	Brick	2.0	1.6	10.5	1.0
E. cloeziana	Earth	1.5	2.3	12.7	3.0
	Steel	1.7	2.9	8.5	1.3
	Brick	2.9	1.7	6.1	1.2
Mixed	Earth	1.6	1.8	15.4	2.9
	Steel	1.7	3.3	9.6	1.2
	Brick	2.1	1.6	7.9	1.1