ALTERNATIVE COOKING FUELS FROM SAWMILL WASTES

O. M. Aina; A. C. Adetogun; M. O. Adedokun, and M. A. Onilude

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[1]Aina, O. M.; [1]Adetogun, A. C.; [1]Adedokun, M. O. and [2]Onilude, M. A.
[1]Dept. of Forestry and Wildlife Management, University of Agriculture, Abeokuta, Ogun State.
[2]Dept. of Agricultural and Environmental Engineering, University of Ibadan, Ibadan, Oyo State.

ABSTRACT
In a conversion efficiency study, 10 sawmills were selected out of the existing 44 in Abeokuta metropolis. For 5 days per week in each of the 10 sampled sawmills, the volumes of all the round logs to be converted each day were determined using Newton's formula. At the end of the days work, the volumes of all lumbers converted were determined and were subtracted from those obtained in the morning, whatever is obtained was the volumes of wood wastes generated in each of the sampled sawmills. This study revealed that the mean conversion efficiency of the 10 selected mills was 56.05%. As a result, the total volume of wood waste generated per day by the 10 mills was approximately 52.00m^3. In the entire Abeokuta metropolis 2288m^3 of wood wastes will be generated per day. When carbonized, 381 tonnes of charcoal will be produced. In conclusion, it is suggested that enormous volume of wood waste generated in virtually all the sawmills in Abeokuta and indeed Nigeria are collected together and be used in the carbonization of charcoal as substitute for kerosene.

Keywords: Charcoal, conversion, lumbers.

INTRODUCTION
The forest estate in Nigeria is estimated at about 10 million hectares, with about 20% in reserve. This forest waste consists of vegetation types ranging from mangrove swamp, lowland rainforest and savanna, progressively into the interior of the country (Olaleye, 1999). Different tropical hardwood species are contained to sustain numerous forest industries in the country. Wood-based industrial operations in Nigeria include timber logging, sawmilling, wood-based panel products manufacturing (i.e. plywood, fibre board and particleboard), furniture/joinery making, paper making, match making, wood seasoning and the manufacture of various wooden items such as tool handles, sport goods, weaving equipment and wooden toys. Also, there are allied industries that make use of forest products for various purposes including building, mining, packaging, leather tanning and others (Hunhtanen, 1975). Sawmilling has been defined as the process of converting round wood from the forests into lumber by using a variety of machines. Some of the machines include bandmills, capable of breaking down logs into desired specifications and re-sawing machines for processing the cants and flitches into specified and marketable dimensions (Lucas, 1975). One factor that has contributed enormously to the rapid depletion of the country's timber resources is wastage of wood during log processing. If wood waste is minimized in the country's sawmills, the number of trees cut per annum for lumber production would be reduced (F.A.C., 1972). One of the major factors contributing to rapid forest depletion in Nigeria and Ogun State in particular is the wastage of wood during log conversion especially in sawmills (Aina, *et al*., 2004).

Another notable source of wood waste occurs in the forest during timber harvesting or felling e.g. harvested and residual tree species. This has constituted a setback to the sustainable management of the forest and the sustainability of the forest industries. In Sarawak, the number of damaged trees varied from one to nine (Noack, 1995), while in Nigeria, there are two problems associated with product harvesting and utilization. These are wastages during harvesting and conversion. The current harvesting techniques in Nigeria results in damages to both the harvested trees and the residual trees (Ojo and Adeola, 1999). The situation is not very different in Ghana, a neighbouring West African country, where wood residues amounted to 50% of which 8-10% are solid wood residues (Noack, 1995). Wood wastes generated during conversion in sawmills in Abeokuta metropolis alone is enormous and, when pooled together, can be used in the carbonization of charcoal and used as alternative source of fuel in homes for cooking.

FAO (1983) estimates that some 400Mm^3 of roundwood a year, about a quarter of all fuelwood, is first converted to charcoal before being used. In cities in developing economies charcoal is a preferred cooking fuel because it is smokeless, light and so cheaper to transport, more energy intensive than wood, and burn with a much hotter flame. In monetary terms charcoal, per unit mass, is approximately ten times more valuable than wood. Wood for charcoal production must first be cut, split and dried because wet wood has a low heat value.

In a traditional charcoal kiln some of the wood is burnt in order to dry the rest of the wood completely, and to raise the kiln temperature until pyrolysis reactions release sufficient heat for the process to become self sustaining (>

300^{0}C). The air vents are then sealed and the volatile gases and tars together with non-condensible gases such as carbon monoxide, carbon dioxide, hydrogen and methane are driven off. Only a proportion of these volatiles is burnt. These chemical by-products are not recovered and much of the potential heat available from pyrolysis is wasted. The temperature stabilizes around 400-450^{0}C (FAO, 1991). When most of the volatile fraction has been driven off, the chimney is also sealed and the kiln allowed to cool. The warm-up time is typically a day, pyrolysis takes 20-30 days to convert most of the wood to charcoal, followed by a cool-down period of equal duration before the charge is unloaded with simple technologies the recovery of charcoal is low, about 15-20% by weight on an oven-dry basis, with at least 6m^3 of roundwood yielding a tonne of charcoal (FAO, 1983). The charcoal has approximately 50% of the energy of the wood, while having only 20% of its original weight. The quality of charcoal from a traditional kiln is quite variable. It depends on the wood, its moisture content and rate of burn. Poorly prepared charcoal can contain as much as 50% by weight of volatile material. This has the advantage of igniting easily but it burns with a smoky flame. Charcoal picks up moisture quite rapidly and when sold, this can range from 5-15%, increasing with increasing impurity of the charcoal (Katzer and Ward, 1979).

MATERIALS AND METHODS

This study was carried out in Abeokuta, the traditional home of the Egbas and capital of Ogun State. The town is made up of the Abeokuta North and South Local Government Areas. Details about the socio-cultural and demographic characteristics of Abeokuta town have been described by Onakomaya *et al*, 1992. There are 44 sawmills in Abeokuta (Aina *et al.,* 2004), out of which 25%, approximately 10, were selected randomly for conversion efficiency studies. No questionnaires were administered as our physical presence of 5 days/wk in each of the 10 sawmills was what it took us to collect all necessary data using (a) measuring tape of 15m length (b) Solid/Hoppu's measure and (c) Newton's formula. The data collected daily from each of the sawmills were separately analysed and later pooled. Correlation coefficients using product moment correlation coefficient (Pearson–Bravars) was used to determine the key factors influencing the efficiency of the milling operation in each of the sampled sawmills.

1. Volumes of each of the logs, before conversion was carried out each day, was obtained using Newton's formula.

$$V_1 = \pi (db^2 + 4dm^2 + ds^2)L/24$$

where,

V_1 = volume of log (m^3)
db = diameter at the large end of log
dm = diameter at midpoint of log
ds = diameter at small end of log
L = Log length (m)
π = 3.142 or 22/7

2. Total volume of the various dimension lumbers obtained per day from timbers in 1 above is obtained using:

$$V_2 = [L \times B \times H]_n$$

where,

V_2 = Volume of sawn lumbers (m^3)
L = Length (mm)
B = Breath (mm)
H = Thickness (mm)
n = Total number of lumbers obtained.

3. The total volume of wood waste generated per day from the conversion of timbers to lumbers is estimated using:

$$Vw = V_1 - V_2$$

where,

Vw = Volume of wood waste (m^3)
V_1 = Volume of round logs before conversion (m^3)
V_2 = Volume of lumbers obtained after conversion (m^3).

4. The percentage waste is therefore calculated using the formula

$$\%\ \text{waste} = \frac{V_w}{V_1} \times \frac{100}{1}$$

5. The efficiency of each of the 10 sampled sawmills calculated using the formula,

$$\xi_{mill} = \frac{V_2}{V_1} \times \frac{100}{1}$$

where,

ξ_{mill} = Sawmill Efficiency (%)
V_2 = Volume of lumbers obtained after conversion (m^3)
V_1 = Volume of round logs before conversion (m^3).

6. Conversion Ratio (CR) for each of the sawmills was calculated using the formula,

$$CR = \frac{\bar{X}V_2}{\bar{X}V_1}$$

where,
CR = Conversion Ratio.
$\bar{X}V_2$ = Mean of total volume of lumbers obtained after conversion (m^3).
$\bar{X}V_1$ = Mean of total volume of round logs before conversion (m^3).

RESULTS AND DISCUSSION

The average number of round logs converted per day, in each of the sampled sawmills, ranges from 12-30 (Table 1). This is greatly affected by the diameter of logs, size of the logs but mostly by the average level of power supply per day. The number of logs converted per day is also determined by the conditions of the bandmills as well as the nature of the logs converted. The maximum number of round logs converted per day in one of the 10 sampled sawmills was 30 and this was recorded in sawmill 4 while the least, 12 logs was recorded in sawmill 10.

Table 1: Average number of logs converted per day.

Sawmill	Average number of logs converted/ day	Average volume of logs converted/ day (m^3)
SM_1	28	13.47
SM_2	17	8.83
SM_3	19	11.82
SM_4	30	16.67
SM_5	14	11.71
SM_6	16	10.28
SM_7	20	9.93
SM_8	19	10.94
SM_9	22	18.67
SM_{10}	12	7.94
Total	197	120.26

Source: Field Survey, 2005.

The average volume of logs converted in the sawmills ranges from 7.94m^3 to 18.67m^3 and this is to a large extent determined by the level of electricity available per day, the size of logs as well as the condition of the bandmills. The highest volume of logs converted was recorded in Sawmill 9. Sawmill 9 uses a CD4 though locally fabricated but with a gear system. This sawmill recorded the highest length of power supply per day because it was the only sawmill that had a stand by generator (Table 1).

SM_4, being the only sawmill with CD6 bandmill, had its operations hindered by the level of electricity supply. From Table 2, Sawmill 9 with 379 lumbers recorded the highest number of lumber production per day while the lowest number of lumber production was recorded in Sawmill 10. Most of the sawmills produced between 200-300 lumbers per day. Perfectly shaped and large diameter sized logs produces higher number of lumbers than large diameter sized but crooked shaped ones.

The average volume of lumbers produced per day ranges from 4.25 to 10.65 m^3. In all the sampled sawmills (SM_1 – SM_{10}) the average volume of lumbers obtained was greater than the volume of waste generated, Table 3.

Sawmills having bandmill operators with less than 10 years experience produced higher volumes of wastes than those with operators having more than 10 years experience. Also from Table 4 it can be seen that the average percentage wood waste generated from each of the 10 sampled sawmills is 44%. This stands to show a recovery rate of 56% (Table 4).

A 44% wood waste generation in the 10 sampled sawmills per day, shows that huge volumes of wood wastes are being generated in Abeokuta. A 56% recovery rate in each of these sawmills shows that a little over half the volume of logs converted per day are good products or lumbers.

Table 2: Average number and volume of lumbers produced per day.

Sawmill	Average number of lumbers produced per day	Average of lumbers produced (m^3)/day
SM_1	289	7.90
SM_2	177	4.96
SM_3	228	6.79
SM_4	345	9.53
SM_5	236	6.77
SM_6	204	5.78
SM_7	202	5.74
SM_8	203	5.74
SM_9	379	10.65
SM_{10}	150	4.25
Total	2413	68.11

Source: Field Survey, 2005.

Table 3: Average volume and percentage of wood waste generated per day.

Sawmill	Average volume of waste generated per day (m^3)	Percentage waste
SM_1	5.57	41.4
SM_2	3.57	41.9
SM_3	5.03	42.5
SM_4	7.14	42.9
SM_5	4.94	42.2
SM_6	4.50	43.8
SM_7	4.19	47.7
SM_8	5.20	47.6
SM_9	8.02	43.0
SM_{10}	3.69	46.5
Total	51.85	x = 44.0

Source: Field Survey, 2005.

Table 4: The Conversion Ratio and Efficiency of the Sawmills.

Sawmill	Conversion Ratio	Efficiency (%)
SM_1	0.59	58.6
SM_2	0.58	58.1
SM_3	0.58	57.5
SM_4	0.57	57.1
SM_5	0.58	57.8
SM_6	0.56	56.2
SM_7	0.52	52.3
SM_8	0.52	52.4
SM_9	0.57	57.0
SM_{10}	0.54	53.5
Mean	0.56	56.1

Source: Field Survey, 2005.

CONCLUSION AND RECOMMENDATION

It was discovered that there is a positive relationship between the shape/form, size of logs converted, types and conditions of bandmills used, length of experience (years) of bandmill operators and conversion efficiency and recovery. The total average volume of wood waste generated per day in the 10 sampled sawmills is 52.0m^3, extrapolating for the 44 sawmills, it therefore mean that a total of 2288m^3 of wood waste will be generated per day in Abeokuta alone. In a month with 6 working days per week, $54,912m^3$ of wood wastes will be generated in Abeokuta only. This enormous volume of wood waste are seen littering the premises of the sawmills in the form of huge piles of sawdust, slabs and offcuts. In most cases these are burnt, with the smoke given off during burning, causing environmental pollution. They are also sold to house wives, food vendors and bakery and a truck load of these wastes cost N2,666 (Aina and Adekunle, 2004). In Nigeria as a whole, one can imagine the volume of wood waste generated monthly.

It will be more advantageous if this enormous volume of wood waste could be pooled together and carbonized into charcoal. From the foregoing, $2288m^2$ of wood wastes per day when carbonized will at worst produce 381 tonnes of charcoal. The charcoal so produced has a higher heat value than wood itself. Charcoal is a good substitute to cooking fuels like kerosene. Charcoal is cheap and affordable to the ordinary Nigerian at a time when kerosene is being refined outside Nigeria and imported into the country at exhorbitant cost that is out of the reach of the common man. This study therefore recommends that a policy be put in place that will ensure the pooling of all sawmill wastes generated in every town or city in Nigeria. It also recommends that pooled sawmill waste pooled be carbonized into charcoal and sold to housewives, food vendors, bakeries, etc. as substitute to kerosene.

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