WOOD WASTE UTILIZATION FOR ENERGY GENERATION

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Abstract

10 medium-scale sawmills were studied for volume of wood waste generation during conversion in Abeokuta, Ogun State. For 10 weeks, data on wood waste generation was collected in each of the 10 sampled sawmills for five effective working days per week. The volumes of all the round logs to be converted each day were determined using Newton's formula. After conversion each day, the volumes of all lumbers converted were determined and were subtracted from those obtained in the morning, whatever was obtained was the volumes of wood wastes generated each day in each of the sampled sawmills. This study revealed that the mean conversion efficiency of the 10 selected mills was 56.05% and as a result, the total volume of wood waste generated per day by the 10 mills was approximately 52.00m^3. In Abeokuta alone with 44 sawmills, 2288m^3 of wood wastes will be generated per day from which 582m^3 of charcoal will be produced.

It is suggested that the enormous volumes of wood waste totaling 104,000m^3 generated in virtually all the sawmills in Nigeria (approximately 2000 in all) be collected together at some designated central points throughout Nigeria, converted into briquettes and carbonized into charcoal be burnt in some specially designed electricity generation plants.

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 (1). 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 (2).

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 (3). The history of sawmilling in Nigeria dates back to the 18th century with pit-sawing as the earliest form of log conversion while the first power-driven sawmill was installed at the beginning of the 20th century (4).

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 (5). 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 (6). Another notable source of wood waste occurs in the forest during timber harvesting. 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 (7), 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 result in damages to both the harvested trees and the residual trees (8). The situation is not very different in Ghana, a neighboring West African country, where wood residues amounted to 50% of which 8-10% is solid wood residues (7).

Wood wastes have been broadly classified into two: avoidable and unavoidable wastes (5). Unavoidable wastes are those wood wastes that cannot be avoided or prevented even where the saw kerf is minimal and the mill workers are efficient. These include sawdust, inconvertible slabs and strips. Avoidable wastes, on the other hand, is caused by lack of (i) pre-inspection of trees and logs, (ii) adequate saw maintenance and (iii) poor harvesting techniques; which results in residues in the forest in the form of branches, tree crowns, off cuts, twigs, stumps, small diameter sized timbers etc. Others include substandard lumbers which are inaccurately processed or converted as a result of faults on both the bandmills and circular resaw machines. Both avoidable and unavoidable wood wastes generated during harvesting and conversion are enormous and, when pooled together, can be used in the production of charcoal for electricity generation in Nigeria which will serve as an alternative to both hydro-electricity and thermal electricity generation.

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 [9]Onakomaya *et al*, 1992.

Data Collection

Based on the work of [10]Aina and Adekunle (2004), it was reported that there are 44 sawmills in Abeokuta 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.

Data Analysis

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 2).

Table 2: Average volume of logs converted per day.

Sawmill	Average volume of logs converted (m^3)/ day
SM_1	13.47
SM_2	8.83
SM_3	11.82
SM_4	16.67
SM_5	11.71
SM_6	10.28
SM_7	9.93
SM_8	10.94
SM_9	18.67
SM_{10}	7.94
Total	120.26

Source: Field Survey, 2005.

SM_4, being the only sawmill with CD6 bandmill, had its operations hindered by the level of electricity supply.

From Table 3, 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.

Table 3: 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.

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 4.

Table 4: Average volume and percentage of wood waste generated per day.

Sawmill	Average 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.

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 5).

Table 5: 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.

A 44% wood waste generation in the 10 sample 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.

Conclusion

From the foregoing 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 was $52.0m^3$, therefore in the whole of Abeokuta with a total of 44 sawmills, $2288m^3$ of wood waste will be generated per day. In a month, considering, 6 working days per week, $54,912m^3$ of wood wastes are generated in Abeokuta only. This enormous volume of wood waste are seen littering the premises of these sawmills in the form of huge piles of sawdust, slabs and off-cuts. In most cases these are burnt, with the smoke given off during burning, causing environmental pollution. 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, formed into briquettes and carbonized into charcoal. The charcoal so produced has a higher heat value than that of wood itself. The charcoal can further be burnt to produce heat or be used to generate steam in specially designed equipment to generate several hundreds of megawatt electricity which can be added to the national grid for onward distribution into homes in Nigeria.

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Biography

MR. O.M. AINA is a Nigerian. He has a Bachelor's degree in Forest Resources Management and a Masters degree in Wood Products Engineering from the University of Ibadan. He is presently a Wood Science Lecturer in the Department of Forestry and Wildlife Management, University of Agriculture, Abeokuta. Nigeria. He is married with four children.