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Research article

MAXIMIZING WOOD RESIDUE UTILIZATION AND REDUCING ITS PRODUCTION RATE TO COMBAT CLIMATE CHANGE

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Abstract

Wood is a renewable natural resource which can effectively reduce climate change. Wood processing operations generate enormous amount of wood residues which need to be efficiently managed. A lumber yield of about 28-64% requires maximizing the economic values of wood. The utilization of wood residue which is deemed as a burdensome waste in many timber industries has the potential of lessening the effects of climate change. This has led to the study of issues associated with the generation and management of wood residues. This research was conducted to examine the rate of wood residue production at the various production lines and its utilization in four selected timber industries in the Ashanti and Brong Ahafo regions of Ghana; and their effects on climate change. Four different timber species, *Cylicodiscus gabunensis* (Denya), *Entandrophragma angolense* (Edinam), *Pterygota macrocarpa* (Koto) and *Triplochiton scleroxylon* (Wawa) were studied. The average lumber recovery percentage at the four sawmills was 38.08% with residue forming 61.92% of the total input volume. It was observed that 9.07% of input volume generated sawdust. However about 60% of this sawdust was not utilized but burnt and/or dumped openly, polluting the environment. It is recommended that the sawdust could be used to manufacture biochar for soil amendment to enhance nurseries, plantations and other agricultural interests.

Keywords: Wood residue utilization, lumber recovery, sawdust, climate change

INTRODUCTION

Climate change is the alteration of the world's climate caused by humans through fossil fuel burning, clearing forests and other practices that increase the concentration of Greenhouse gases (GHG) in the atmosphere. Greenhouse gases are the gaseous components of the atmosphere that traps heat in the air. The forest resource serves as medium for reducing greenhouse gas emissions by absorbing carbon dioxide for photosynthesis and storing carbon in its system (FPAC, 2009). One of the factors that contribute to climate change is forest degradation. The forest resources of any country require efficient utilization to ensure its sustainability so as to reduce its effects on climate change (UNISDR, 2008).

The bulk of Ghana's timber is located in the country's high forest zone. However, most of the original forest in this area has been cleared and the remaining closed canopy forest is now to be found in forest reserves and a few patches of unreserved forests (Cargill Technical Services Limited, 1993). An Annual Allowable Cut (AAC) has been set at two million cubic meters (2,000,000m^3) for round logs. However, the demand for wood is so alarming that this AAC is woefully inadequate to meet the nation's demand for wood. The amount of timbers harvested at 2005 was 2,315,000m^3 giving a deficit of over 300,000m^3 (TIDD, 2010), thus posing a threat on the long term sustainability of the timber industry.

Large volumes of the logs that come into most timber industries are not efficiently utilized leading to high rates of residue generated from logging, wood processing and storage processes (Magin, 2001). The production of high volumes of residue brings the natural forest which is the main source of raw material for the wood industry under threat. Using wood carefully with minimum waste is a vital component of sustainable timber use, but this has been less of a focus to date (Magin, 2001). Wood residues like sawdust, trimmings and edgings are typically viewed as a burdensome disposal problem (FAO, 1990), however, the material has a potential to become a usable resource. Ghana is in a position to take up this advantage since the timber industries have average yield of about 28-64% (Gyimah and Adu-Gyamfi, 2009), with majority of the wood resources going to waste.

To take advantage of the market opportunities that exist for wood residues, information is needed on their availability, quantity and production rates, types of wood residues being produced, current markets and current disposal practices (Alderman, 1998). Wood residue could be decomposed in the soil to improve soil structure and fertility for food crops to enhance food security. Thus, there will be no need to clear more hectares of land for same quantity of food, hence forest maintained. Also, plantation crops could be fertilized with biochar which is a carbonaceous material produced by thermal decomposition of wood with limited supply of oxygen and a relatively low temperature ($<700^{o}C$). Biochar is produced specifically for the application to soil as part of agronomic or environmental management (Lehmann and Joseph, 2009). Biochar is very stable hence the carbon remains sequestered in the soil for a long time and contributes to the mitigation of climate change (Lehmann, 2007a). The main objective of the study was to assess the efficiency of production, utilization and environmental effects of wood residue. This study dealt with the maximization of wood residue usage to mitigate climate change.

MATERIALS AND METHODS

This study focused only on the wood processing residues from the sawmill. It did not consider forest residues produced in the process of logging or land clearing. Four timber industries were selected from the Ashanti and Brong-Ahafo Regions of Ghana. Four different timber species (140 logs) were used in the research and this was based on the most frequently processed in the study sites (this was retrieved from the export document of the companies). The species were *Cylicodiscus gabunensis* (Denya), *Entandrophragma angolense* (Edinam), *Pterygota macrocarpa* (Koto) and *Triplochiton scleroxylon* (Wawa).

In estimating the volume of sawn logs, two diameters perpendicular to each other, including the shortest diameter were taken from both the butt and the tapper ends, which excluded the bark. Steel tape was used in the measurement of the diameter while the lengths of the logs were taken with a fibre tape. The average diameter (D_{av}) was given by adding the four diameters and dividing by four. This value and the length of the log were used for the calculation of the log volume in metres cube. Volume calculation of each of the logs, before processing was carried out using the Smalian's formula,

$$V_{l} = 0.7854D_{av}^{2}L\ (m^{3})$$ **Equation 1** (Brack and Wood, 1997)

Where,

V_l = volume of log (m^3),

D_{av} = Average diameter of the logs (m),

L = Log length (m)

0.7854 = Constant

The volume of products produced along the various machine centres calculated using the following formula:

The formula for the volume of the fixed width lumber was given by;

V_2= [L x W x T] n **Equation 2**

Where,

V_2 = Volume of sawn lumbers (m^3)

L = Length (m)

W = Width (m)

T = Thickness (m)

n = Total number of lumber pieces obtained.

The random width lumber was tallied. The length, width and thickness, were measured and the volume was given by;

V_2= L x T x W_t **Equation 3**

Where,

V_2 = Volume of sawn lumbers (m^3)

L = Length (m)

W_t = Total Width of all lumber (m)

T = Thickness (m)

The total recovery was given by the sum of the volume of the trimmed lumber. The percentage yield or percentage recovery was given by the ratio of the volume of the lumber to the volume of the input log in metres cube expressed in percentage as defined by Tsoumis (1991).

The Recovery Rate was calculated using the formula,

$RR = \frac{V_2}{V_1} \times 100$ **Equation 4**

Where,

RR = Recovery Rate (%),

V_2 = Volume of lumbers obtained after conversion (m³),

V_1 = Volume of round logs before conversion (m³)

The total volume of wood residue generated from the conversion of logs was given by the difference between the log volume and the total lumber volume and was calculated using:

$V_R = V_1 - V_2$ **Equation 5**

Where,

V_R = Volume of wood residue (m³)

V_1= Volume of round logs before conversion {bolt} (m³)

V_2 = Volume of lumber obtained after conversion (m³).

The percentage residue was therefore calculated using the formula

Percentage of residue = $\frac{V_R}{V_1} \times 100$ **Equation 6**

The various classes of residues were identified through observations along the production lines. The existing uses of the wood residues at the various sawmills were identified through site observations and questionnaires to the production managers and supervisors.

RESULTS AND DISCUSSION

The findings of the study are presented in tables and charts below.

Table 1: Summary Yield results for all species (*Cylicodiscus gabunensis* (Denya), *Entandrophragma angolense* (Edinam), *Triplochiton scleroxylon* (Wawa) and *Pterygota macrocarpa* (Koto))

Machine Type	**Input Volume (m³)**	**Output Volume (m³)**	**Residue Volume (m³) Coarse**	**Sawdust**	**TOTAL**	**% of Total Residue**
Bandmill	**249.895 [a]**	**190.096**	**42.009**	**17.790**	**59.799**	**23.93**
Edger	**190.096**	**122.735**	**63.193**	**4.168**	**67.361**	**35.43**
Trimmer	**122.735**	**95.150 [b]**	**26.869**	**0.716**	**27.585**	**22.47**
TOTAL VOLUME OF RESIDUE (m³)			**132.071**	**22.674**	**154.745**	

[a] Log input, [b] Lumber (Final output)

Source: Field Survey, 2012

$$\text{Lumber Recovery \%} = \frac{95.150}{249.895} \times 100$$

$$= \mathbf{38.08\%}$$

Wood Residue % = **61.92%**

Table 1 is a summary result for all the species. The total volume residue generated was 154.745m^3. The band mill was made up of 42.009m^3 coarse residue (slabs) and 17.790 m^3 sawdust. The edger was made up of 63.193m^3 coarse residue (edgings) and 4.168 m^3 sawdust; and the trimmer was made up of 26.869m^3 coarse residues (trimmings) and 0.716 m^3 sawdust. The total sawdust of the production process was 22.674m^3. The production process produced four types of residue: slabs constituted 27.15% of residues, edgings constituted 40.84% of residues, trimmings 17.36% of residues and sawdust 14.65% of residues. The total input volume was 249.895m3 with recovery of 38.08% and 61.92% residue. With reference to the input volume, lumber constituted 38.08%, slabs 16.81%, edgings 25.29%, trimmings 10.75% and sawdust 9.07%.

From Table 1, it is observed that the average percentage recovery for the logs processed was 38.08%, which ranged from 33.27% to 44.91%. This is in line with Noack (1995) who reported that lumber recovery ranged from 36% to 57%. Gyimah and Adu-Gyamfi (2009) after a pilot study on sawnwood conversion efficiency in selected sawmills in Ghana indicated that the mean recovery for small to large scale enterprises ranged from 28% to 64%. Lumber recovery in sawmills is also put at 30-45% of the log input (Nketiah *et al.*, 2001). Between 1909 and 1990, Ghana lost 80% of its forest with 65,000 ha vanishing annually and 115,400 hectares between the years 2000 and 2005 all due to excessive logging and low recovery rates (Dogbevi, 2008; Bank of Ghana, 2004). There is the need to reduce the volume of wood harvested by making maximum utilization of the wood. The effects of excessive logging on climate change can be reduced by utilizing the wood residue. About half of the total mass of wood is made up of carbon which still remains even after harvesting and it is only released when burnt or through decomposition. Hence wood residue usage helps to contain carbon in the wooden product instead of releasing it into the atmosphere to cause global warming (FPAC, 2009; Nabuurs *et al.*, 2007).
Figure 2 which is a summary of the production processes showed that the average percentage residue that was produced as a percentage of total residue volume at the bandmill was 38.64%; that for the edger was 43.53%; and that for the trimmer was 17.83%.

According to Agyeman (1998), a comparison of residues generated as percentage of their total residue volumes indicated that the edger generated the highest percentage residue, followed by the bandmill and then the trimmer. However, in order to offset the effect of the machine centres not fed with the same wood input volume, the percentage input volumes were what was considered for the comparison of the residues generated. This is in line with Figure 2, which shows that the average percentage residue generated as a percentage of total residue volume that was produced at the edger was 43.53%; that for bandmill was 38.64%; and that for the trimmer was 17.83%. In general, the study has revealed that the edger generates the most residues in the sawmilling

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manufacturing process. It also shows that residues (edgings) generated at the edgers are often more than the slabs (bandmills) which are also more than the trimmings (trimmers) in sawmilling residues (see Fig. 2).

The residues identified in the production process were:

- Sawdust: This is the fine particles of wood that are created when wood is cut with a toothed saw, because the saw creates a path by removing wood. It can range from dust size to clumpy grains. It is a breathing hazard. Sawdust was common along the production lines; the bandmills, edgers and trimmers. Sawdust constituted about 14.65% of the residues generated (Table 1).
- Slabs: Slab is the first and last piece of lumber removed when squaring a log (Martyr, 1972). They are produced at the band mill. Slabs also constituted about 27.15% of the residues generated (Table 1).
- Edgings: These are produced at the edger where lumber is cut to the required width. They formed about 40.84% of the residues generated (Table 1).
- Trimmings: They are the residues produced after lengthwise cutting of the edged boards and they are as thick and wide as the final product. They were produced at the trimmer where length of lumber is cut to contract specifications. They form about 17.36% of the residues generated (Table 1). The defective lumber was added to the trimmings.

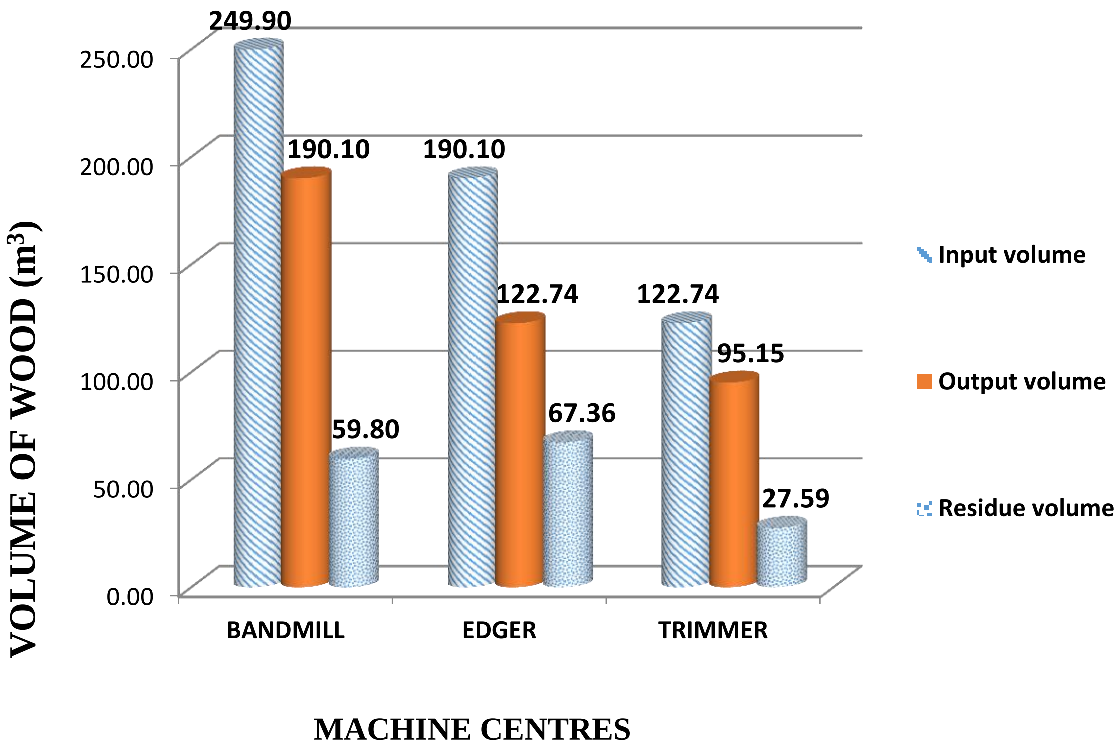

Fig. 1: Volumes of wood at various machine centres for *Cylicodiscus gabunensis* (Denya), *Entandrophragma angolense* (Edinam), *Triplochiton scleroxylon* (Wawa) and *Pterygota macrocarpa* (Koto) at all the Companies

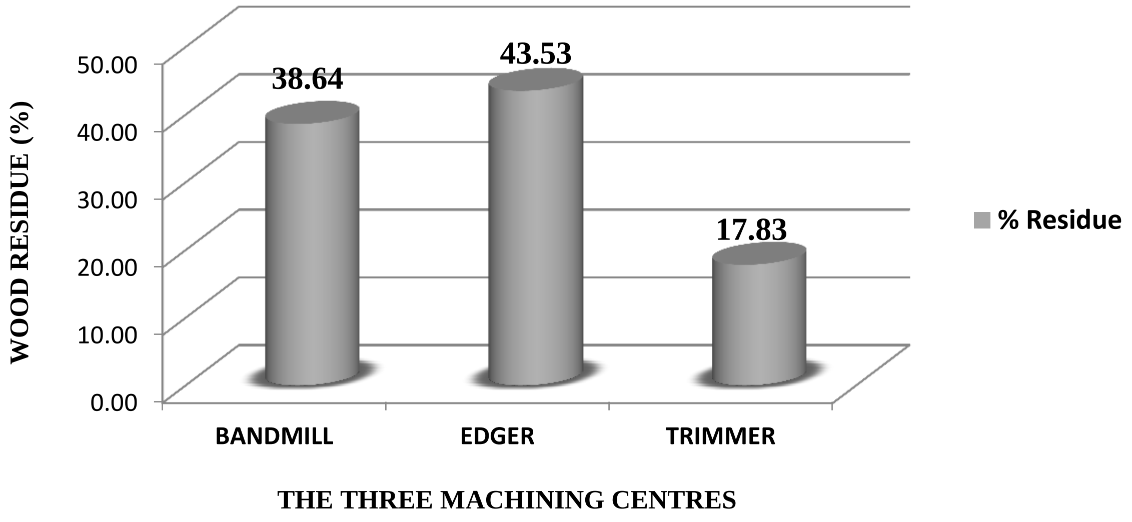

Fig. 2: Residues generated from the machine centres as a percentage of total residue volume for all the companies

Table 2: A summary of residue utilization at the various sawmills

Type of Residue	Volume (m^3)	Recovered (%)	Recovered (m^3)	To Furnace (%)	Sold (%)	Discarded (%)
Slabs	42.009	5.00	2.100	20.00	75.00	0.00
Edgings	63.193	5.00	3.160	90.00	4.00	1.00
Trimmings	26.869	20.00	5.374	75.00	4.00	1.00
Sawdust	22.674	0.00	0.000	40.00	0.00	60.00

Source: Field Survey, 2012

According to Table 2, the Total Volume recovered through further processing was given by the sum recovered from the slabs, edgings and trimmings, given by:

Volume from further Processing = $(2.100 + 3.160 + 5.374)\ m^3 = 10.634 m^3$

From Table 1, the volume of the original output was $95.150 m^3$ and original input was $249.895 m^3$.

Residue recovered % = $\frac{10.634}{249.895} \times 100$

= **4.26%** of Input Volume

The New Final recovery is given by:

$$\text{Final Recovery (\%)} = \frac{(Original\ Volume\ Output + Volume\ from\ further\ processing)}{Original\ Volume\ Input} \times 100$$

$$= \frac{95.150 + 10.634}{249.895} \times 100$$

$$= \frac{105.784}{249.895} \times 100$$

= **42.33%**

New Residue (%) = 100 – 42.33 = **57.67%**

From Table 2 it is deduced that about 27% (35.110m^3) of the coarse residue was sold.

According to Brink (2003), the idea that wood can be recycled or reused and not hauled straight to the landfills, makes sense. This is in line with Table 2, apart from the sawdust which had about 60% being discarded, only about 2% of the coarse residue was discarded. This was confirmed by Bogart (2004) who stated that the least favored option for residue is sending the material to a landfill; however, significant amounts are still land filled or burned without energy recovery. Dost (1966) defined wood residue as the remnant of the original raw material after the economic value has been removed. This means the 4.26% of Input Volume that was recovered from downstream processing has gained a kind of economic value which will cause the net profit of the sawmill to increase.

Waste prevention and recycling reduces greenhouse gases associated with those activities by reducing methane emission and increasing forest carbon sequestration. The disposal of wood waste produces greenhouse gas emission in a number of ways:

- Anaerobic decomposition of waste produces methane, a greenhouse gas 21 times more potent than carbon dioxide.
- The transportation of waste to disposal sites produces greenhouse gas emissions from the combustion of the fuel used in the equipment.
- The disposal of materials indicates that they are being replaced by new raw materials, hence the depletion of the forest – trees absorb CO_2 from the atmosphere.

The International Solid Waste Association (ISWA, 2009) has developed a waste hierarchy which is a valuable conceptual and political prioritization tool which can assist in developing waste management strategies aimed at limiting resource consumption and protecting the environment. As a result, priority is given to waste minimization, re-use, recycling, waste-to-energy, and finally landfill.

CONCLUSION

The study constitutes an attempt to promote the use of abundant but overlooked wood residues in Ghana through providing trustworthy data about the various types, quantities and uses. This huge volume of wood residue (forming 61.92% of the input volume) generated poses environmental and health challenges to the surrounding communities. This might contribute to reduce pressure on the forest by increasing the volume of output (yield) extracted per unit area, making harvesting and processing more financially viable.

RECOMMENDATIONS

- In order to ensure the efficient use of wood residue in Ghana and to protect our forest from deforestation by excessive logging, sawmilling industries would have to educate their staff through research and workshops on recycling a lot more wood residue so as to harvest the forest on a sustainable basis.
- The Government should consider offering investment tax credit, tax deferments or other types of incentives to businesses that are interested in utilizing wood residues in their manufacturing processes.
- Wood residue producers should form partnership which would facilitate the transportation, storage and marketing of wood residues. They could also consider value-added manufacturing processes of solid wood residue such as finger joints, crafts and toys, floorings and garden fencing. Also fines like the sawdust could be used to manufacture bio-char for soil amendment to enhance nurseries, plantations and other agricultural interests.
- There should be laws and regulations governing open burning of sawdust which has a negative effect on climate change.

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