Impediments to Wood Waste Generation for Particle Board Production: A Study Of Sawmill Industries in Niger State, Nigeria

Robert O. Okwori[1], Stephen S. Ochigbo[2] and Opeyemi D. Alawode, [3]
[1&3,] Departments of Industrial and Technology Education (Building/ Woodwork Technology education)
[2]Department of Chemistry Federal University of Technology, Minna, Niger State.
Corresponding Author: +2348060966524robertokwori@futminna.edu.ng

Abstract

The purpose of the study was to determine the impediments to wood waste generation for particle board production in sawmill industries in Niger state, Nigeria. The study covered sawmills in the twenty-five (25) local government areas of Niger state Nigeria. Descriptive survey research design was adopted for the study. A population of eighty-eight (88) respondents was used for the study. Three research questions were raised to guide the study while three hypotheses were formulated to test the hypotheses. The reliability coefficient of the instrument was determined using Cronbach alpha formula and it was found to be 0.85. Structured questionnaire was used for data collection. Mean and standard deviation were used to answer research questions while analysis of variance (one-way ANOVA) was used to test the hypotheses at 0.05% level of significance. Based on the data collected and analyzed, the findings of the study were use of obsolete equipment, Problem of deforestation, lack of technical personnel to operate the machines, poor relationship existed between the sawmill managers and the staff and there was no staff training. It was recommended that government should enforce the law on deforestation to facilitate tree growth that can enhance wood waste generation for particle board production, The sawmill managers should organize training for the staff on effective use and maintenance of woodworking machines. Modern woodworking equipment should be procured to enhance efficiency and effective woodworking operations with minimum effort.

Keywords: Particle, Board, Wood, Waste, Sawmill

Introduction

Wood is a product obtained from trunks and branches of trees. Wood as a natural plant-based polymer plays vital roles in the provision of comfortable living conditions for humans. Wood is one of the environmental building materials derived from forest and it contributes significantly to national economic development of the country (Yisa, Okwori & Hassan, 2021). Wood is processed into various sizes for diverse applications, including fuel, furniture, civil engineering, building construction, automobile, and aerospace works, with wood waste inevitably generated during these processes.

Waste is any substance termed as unwanted item and discarded after the main part has been used. These items discarded are later used for other purposes such as fuel, particle board (PB) among others. Wood wastes are wood products obtained as a result of wood processing and its wastes are saw dust, wood chips, wood shavings, wood dust from sanders, circular saw and hand saws during ripping and cross cut operations. The wood dust is also obtained when carrying out operations using bandsaw machine surface planer, thicknesser and circular saw machine. Wood wastes used for PB production are generated from the process of converting log of wood into different useful products in sawmills including construction of furniture items (Ikubanni *et al*., 2024; Amarasinghe *et al*., 2024)**.** The four main sources of wood wastes generation are from

felling the tree and converting the log into timber, during construction of furniture items, cutting of timber for formwork during road construction and also processing of timbers in sawmills for different purposes for (Nwancho *et al.,* 2023).

A sawmill is a facility where timber is processed through operations such as cutting, planning and jointing, resulting in the generation of sawdust from both softwood and hardwood. In addition to timber processing, minor construction activities particularly joinery works like doors, windows, lintels, and formwork are often carried out. Sawmills are classified by location into urban, semi-urban, and rural types (Science Direct, 2024). Urban sawmills are typically large-scale and well-equipped, semi-urban sawmills are moderately developed, while rural sawmills are smaller and less mechanized, often situated in areas with abundant vegetation (AU-eJIR, 2021). The sawmill industries are staffed by managers, machine operators, saw doctor, labourers and workers to ensure efficient operations (ITTO, 2021; FAO, 2022). Overall, timber processing in sawmills generates significant wood waste, which can be utilized for particleboard production.

PB is a composite engineered wood product manufactured from wood particles, such as wood chips, sawmill shavings, saw dust, and a synthetic resin or other suitable binder mixed with wood particles and pressed together to form board. PB is commonly manufactured in a three-layer structure, consisting of top face layer (upper surface: made of fine wood particles for smoothness and finishing), core layer (middle layer: composed of coarse wood particles for strength and bulk) while the bottom face layer (lower surface: made of fine particles to provide a smooth backing and balance the board). It is widely utilized for both domestic and industrial applications, particularly in furniture production and interior construction.

Additionally, PB is suitable for decorative purposes such as overlaying, laminating, and inlaying with other materials due to its smooth finish. In construction, it is used for ceiling panels, flooring underlays, wall partitions, and the fabrication of building components such as housing units and kiosks (Kushwaha, 2025). The demand for PB in Nigeria is increasing daily for domestic and industrial use as it demands the use of less energy during construction, easy to use and has wider surface when compared to solid wood. Availability of wood waste will enhance production of pb and will also boost the economy of the country as a whole.

Statement of the Problem

PB is a man-made board produced from wood particles such as wood chips, wood shavings or wood sawdust with the application of adhesive. Pb has wide application, therefore, there is a need for enough wood waste for production of particle boards. In the past, saw mill industries generated a lot of wood waste for particle board production but today sawmill industries especially in Niger State are facing constraints in generating wood waste. One wonders what could be responsible for inadequate wood waste generation in sawmills for particle board production in Niger State. The result of deforestation in Nigeria forest and the choice of purpose of trees mighty have similarly attributed to the reduction in the number of sawmills and wood waste generation in the country (ITTO, 2021; Amarasinghe, *et al,* 2024). The diminishing of wood waste, automatically affect particle board production in Nigeria. Therefore, there is a need for increase in particle board production as the demand for it, is perpetually increasing due to expansion of construction industries and houses in Nigeria due to increase in population.

Objectives of the Study

The objectives of the study are to determine the impediments to wood waste generation in sawmills in Niger State, Nigeria for particle board production. Specifically, the study sought to:

1. Determine the factors hindering waste wood generation for particle board production in the era of uncertainties in Nigeria state.
2. Ascertain the organizational practices towards waste wood generation for particle board production in the era of uncertainties in Nigeria state.
3. Find out how activities of sawmill are planned towards wood waste generation for particle board production in the era of uncertainties in Nigeria state.

Research Questions

The following research questions guide the study.

1. What are the factors hindering waste wood generation for particle board production in the era of uncertainties in Nigeria state?
2. How are sawmills organized towards waste wood generation for particle board production in the era of uncertainties in Nigeria state?
3. How are the activities planned in sawmills towards wood waste generation for particle board production in the era of uncertainties in Nigeria state?

Hypotheses

The following hypotheses were tested at 0.05 level of significance.

1. There is no significant difference in the mean responses between the managers, sawmill supervisors and machine operators on factors hindering wood waste generation for particle board production in the era of uncertainties in Nigeria state.
2. There is no significant difference between the mean responses of managers, sawmill supervisors and machine operators on how activities are organized towards wood waste generation for particle board production in the era of uncertainties in Nigeria state.
3. There is no significant difference between the mean responses of managers, sawmill supervisors and machine operators on how activities are planned in the sawmills towards wood waste generation for particle board production in the era of uncertainties in Nigeria state

Methodology

The study adopted descriptive survey research design. The study was conducted in Niger State of Nigeria. The state had twenty-five (25) local government areas. The population for the study consisted of 88 respondents. Twenty-two (22) managers, 44 machine operators and 22 sawmill supervisors in sawmill industries. The total population used for the study was eighty-eight (88). It was a manageable size so there was no sampling.

Structured questionnaire was used as instrument for data collection. It consisted of 48 items developed by the researchers. Section (A) solicited for information on factors hindering wood waste generation for particle board production. Section (B) elicited information from respondents

on organizational practices towards wood waste generation for particle board production. Section (c) sought information from respondents on how the, activities are planned in sawmills towards wood waste generation for particle board production. Five points rating scale was used as follows: Strongly Agree (SA) =4.5-5.00, Agreed (A) =3.5- 4.49, Moderately Agree (MA) =2.5-3.49, Disagree (DA) = 1.5-2.49, Strongly Disagree (SD) = 0.5- 1.49. The decision was taken by applying the principles of lower and real upper limits of scale 1 to 5 on a five-point rating scale.

The drafted instrument was subjected to face and content validation by three experts, two from the Department of Industrial and Technology Education, Federal University of Technology, Minna and one sawmill manager. Cronbach alpha formula was used to determine the internal consistency of the instrument. Seventeen copies of the instrument were administered, 5 for managers, 10 for machine operators and 2 for saw doctors in Jebba South of Kwara State. The reliability coefficient of the instrument was determined to be 0.86. The instrument was administered to the respondents by three research assistants. The research assistants were briefed on how to administer and collect the questionnaire from the respondents. The questionnaire collected were eighty-eight (88) that is returned rate was 100%.

Mean and standard deviation were used to answer research questions while, one-way analysis of variance (one-way ANOVA) was used to test hypotheses 1, 2 and 3 at 5% level of significance. Decision on the research questions was based on the result of mean scores interpreted based on the concept of real lower and upper limit of numbers as shown above. Decision on the hypotheses was based on comparing the significant value (level of significant) with ($P \leq 0.05$). If the significance value is equal or greater than ($P \leq 0.05$), the hypothesis is upheld or otherwise rejected.

Results

Research Question One: What are the factors hindering waste wood generation for particle board production?

Table 1: Mean responses of respondents on factors hindering waste wood generation for particle board production

S/N	ITEM	Mean	SD	RK
1.	Availability of woodworking machine spear parts in the store	2.38	0.98	DA
2.	Poor power supply to sawmill industries	4.06	0.74	SA
3.	High cost of repairing and maintaining woodworking machines	3.16	0.91	MA
4.	Sawmill stores lack safety equipment	3.49	1.04	MA
5.	Machines are not positioned in order of Operations	4.22	0.75	SA
6.	Complied with woodworking methods of operations	2.38	0.85	DA
7.	Timber's exportation affects wood waste generation	2.17	0.84	DA
8.	Lack of access road to sawmill industry	3.24	0.94	MA

9.	Outlined procedures for enhancing wood waste generation	2.49	0.87	DA
10.	Poor illumination in the working area	3.28	1.14	MA
11.	Obsolete equipment	3.26	1.28	MA
12.	Lack of personnel to operate the machines	3.07	1.38	MA
13.	Cost of felling trees and transportation of wood to sawmills is cheap	2.36	1.09	DA
14.	Cost of fuel for operating woodworking machines is cheap	2.38	1.04	DA
15.	Woodworking operations outside sawmill affects wood waste generation	2.04	1.13	DA
16.	Problem of deforestation	3.26	0.86	MA
17.	Wood processed for joinery work do not generate enough wood waste	2.28	1.11	DA
	GM	**2.91**	**1.00**	**MA**

Key: SD is standard deviation, N is number of respondents, G M is Grand Mean

Table 1 showed that respondents agreed with items 2,3,4,5,8,10,11,12,16 and disagreed with items 1,6,7,9,13,14,15 and 17. This means respondents disagreed with availability of woodworking machine spear parts in the tool store, complied with working methods and operations, timber exportation affects wood waste generation, outlined procedures for enhancing wood waste generation, cost of felling trees and transportation of the log is cheap, cost of fuel for operating woodworking machines is cheap and woodworking operations outside sawmill affect wood waste generation and wood processed for joinery work do not generate enough wood waste.

Research Question Two: How are the activities in sawmills organized towards wood waste generation for particle board production?

Table 2: Mean responses of respondents on how activities in sawmills are organized towards waste wood generation for particle board production.

S/N	ITEM	Mean	SD	RK
1.	Sequential arrangement of machines for facilitating wood waste generation.	3.48	0.76	MA
2.	Tools are organized in the tool store rooms	2.29	0.69	DA
3.	Materials are arranged before and after use in their respective places	2.26	0.72	DA
4.	Records are properly kept to facilitate wood waste generation	2.24	0.96	DA
5.	Machines are organised for effective inspection and identification of worn-out nuts and parts	3.34	0.82	MA

6.	Hazardous substances are securely stored and under control.	3.26	0.91	MA
7.	Electric tools and hand tools are regularly checked to avoid loss to facilitate wood waste generation	2.32	0.82	DA
8.	Equipment and materials are used for the purpose in which they are made for.	3.34	0.71	MA
9.	The working environment are neatly kept for free movement of staff and materials.	3.34	0.99	MA
10	Preventive maintenance is usually carried out to prevent breakdown of equipment in the sawmill	3.42	0.88	MA
11.	Machines are used based on their functions	3.39	0,86	MA
	GM	**2.97**	**0.83**	**MA**

Key: $\bar{x}$vg is average mean of the three groups, SD is standard deviation, N is number of respondents, GM is Grand Mean

The data presented in table 3 shows that respondents agreed with seven items and disagreed with 4 items (2, 3, 4 & 7). Respondents disagreed with statements (items) such as tools are organized in the tool store rooms, materials are arranged before and after use in their respective places. Records are properly kept to facilitate wood waste generation, electric tools and hand tools are regularly checked to avoid loss to facilitate wood waste generation.

Research Question three: How are the activities of sawmill planned towards wood waste generation for particle board production?

Table 3: Mean responses of respondents on how sawmill activities are planned towards waste wood generation for particle board production.

N=88

S/N	ITEM	Mean	SD	RK
1.	Made provision for new tools in case of damaged ones.	3.42	0.89	MA
2.	Spare parts are kept in case of fault or damage parts	2.37	0.96	DA
3.	Proper planning of human and material resources towards wood waste generation	3.15	0.90	MA
4.	Availability of consumables (engine oil) for generating wood waste	3.49	1.02	A
5.	Positioning woodworking machines based on machine shop layout	4.22	0.76	A
6.	Machines are examined before generating wood waste	2.17	0.83	DA
7.	Provision of access road to sawmill for processing and conveying wood Waste for particle board production	3.24	0.94	MA
8.	Outline working procedure for effective generation of wood Waste for particle board production	3.24	0.94	MA
9.	Provision of adequate illumination for effective use of machines	4.06	0.74	MA
10.	Adequate provision for natural lighting in the working area	3.28	1.19	MA

11.	Planned for routine maintenance of machines to avoid obstacle to wood waste generation	3.26	1.28	MA
12.	Planned for safety items and devices for machine operator, machines and materials	3.06	1.29	MA
13.	Planned for weekly maintenance of machines towards wood waste generation	2.35	1.08	DA
14.	Keeping inventory of machine parts and materials	2.04	1.13	DA
15.	Developed strategies for achieving goals as regards wood waste generation	2.39	1.02	DA
16.	Planned orientation for new staff annually	3.28	0.86	MA
17.	Planned for fuelling generating plant weekly in case of power failure for wood waste generation	2.28	1.10	DA
	Grand Mean	**2.96**	**1.00**	**MA**

Key: $\bar{x}$vg is average mean of the three groups, SD is standard deviation, N is number of respondents, GM is Grand Mean

Table 3 revealed that respondents agreed with 11 items and disagreed with 6 items (6, 13, 14, 15 & 17). This reveals that these items such as machines are examined before generating wood waste, planned for weekly maintenance to prevent obstacle to wood waste generation, keeping inventory of machine parts and materials, developed strategies for achieving goals as regards wood waste generation and planned for fuelling generating plant weekly in case of power failure for wood waste generation.

Hypothesis 1: There is significant difference in the mean responses between managers, sawmill supervisors and machine operators on factors hindering wood waste generation for particle board production.

Table 4: One-way ANOVA of mean scores of respondents on factors hindering wood waste generation for particle board production

Source	Sum of Squares	Df	Mean Square	F	Sig
Between groups	0.481	2	0.241	1.177	0.314
Within groups	17.125	84	0.204		
Total	17.606	86			

The analysis in table 4 revealed the ANOVA on factors hindering wood waste generation for particle board production. The analysis disclosed that the p-value (0.31) is greater than 0.05 level of significance, the null hypothesis was accepted. This means there is no significant difference in the mean responses between managers, sawmill supervisors and machine operators on the factors hindering wood waste generation for particle board production.

Hypothesis 2. There is significant difference in the mean responses between managers, sawmill supervisors and machine operators on organizational practices towards wood waste generation for particle board production.

Table 5: One-ANOVA of mean scores of respondents on organizational practices towards wood waste generation for particle board production

Source	Sum of Squares	Df	Mean Square	F	Sig
Between groups	0.622	2	0.312	1.906	0.155
Within groups	13.686	84	0.162		
Total	14.308	86			

Table 5 showed the ANOVA on organizational practices towards wood waste generation for particle board production. From data presented above, it revealed that the p-value (0.11) is greater than 0.05 level of significance so the null hypothesis is upheld. Therefore, there is no significant difference in the mean responses between managers, sawmill supervisors and machine operators on coordinating practices towards wood waste generation for particle board production.

Hypothesis 3: There is significant difference in the mean responses between managers, sawmill supervisors and machine operators on planning practices towards wood waste generation for particle board production.

Table 6: One-ANOVA of mean scores of respondents on planning practices towards wood waste generation for particle board production.

Source	Sum of Squares	Df	Mean Square	F	Sig
Between groups	0.041	2	0.241	1.177	0.314
Within groups	17.124	84	0.204		
Total	17.165	86			

In Table 6 presented above, the ANOVA on planning practices towards wood waste generation for particle board production revealed that the p-value (0.31) is greater than 0.05 level of significance. Thus, the null hypothesis is accepted. This shows that there is no significant difference in the mean responses of managers; sawmill supervisors and machine operators on planning practices towards wood waste generation for particle board production.

Findings of the study

Based on the data collected and analyzed, the following findings emerged:

1. Wood waste generation in sawmills is significantly hindered by operational challenges such as poor power supply, obsolete equipment, inadequate machine arrangement and shortage of skilled personnel.
2. Effective organizational practices including proper machine arrangement, maintenance culture, safety management, and orderly work environments among others.

3. Strategic planning measures like resource provision, machine layout design, routine maintenance, and staff training, enhance efficient wood waste generation for particleboard production.

Discussion of the findings of the study

Use of obsolete equipment was one of the findings revealed in table 1. In support of this finding, Akinyemi & Olorunnisola (2020) revealed that advanced sawmill industry uses computers, conveyors, scanners, lasers, digital cameras and bar-coding systems to improve sawmill efficiency. Therefore, there is a need for modern equipment in sawmills to enhance efficiency. With reference to availability of adequate ventilation and illumination in sawmills industries, this finding is in agreement with (Mohammed, 2017; Occupational Safety and Health Administration (OSHA), 2023) who disclosed that there should be proper ventilation and illumination in sawmills to enhance visibility and dissipation of heat. As regards planned for safety items and devices for machine operators, machines and materials, AU-eJIR (2021) stated that hazard in sawmills can be reduced when safety equipment are provided and safety practices are observed. Ikubanni *et al*. (2024**)** disclosed that sawmill managers should ensure workers wear hand grooves apron and ear muff when using machines. Amarasinghe *et al*. (2024) stated that safety measures should be observed during wood processing to avoid injury to the machine operator, damage to the equipment and material.

In relation to findings on Hypothesis one, it revealed that there was significant difference in the mean responses of managers, supervisors and machine operators on ways sawmills industries are planned. Shearing the same opinion, International Labour Organization (2021) emphasized on effective planning of sawmill industries. With reference to organization of machines in sawmill industries, it was revealed that arrangement of machines in sawmill industries enhances productivity by following operation sequence. Ogunsaju (2016); Akinyemi & Olorunnisola (2020) stated that organization is the arrangement of resources which includes human, tools and equipment and it should be properly organized to enhance efficiency and output expected in a day. In relation to the finding of the study that indicated proper keeping of records of sawmill industries, Yisa, Okwori and Hassan (2021) mentioned ways of record keeping which includes: consumables, tools and equipment purchased. Another record keeping include consumables used, damaged tools that needs replacement among others. Findings on Hypothesis two revealed that there was significance difference in the mean responses of managers, supervisors and machine operator on organization of sawmills. Nwancho, Okwori, Maik & Igwe, (2023) revealed that for sawmills to achieve its aim and objectives, it needs organizational effectiveness.

Conclusion

The study concludes that wood waste generation in sawmills for particleboard production is strongly influenced by operational, organizational, and planning factors, as well as environmental constraints such as deforestation, which reduces the supply of wood logs. Major challenges include obsolete equipment, poor power supply, inadequate machine arrangement, and shortage of skilled personnel, all of which limit efficiency. However, effective organizational practices such as proper machine sequencing, maintenance culture, safety compliance, and orderly work environments significantly enhance productivity. Strategic planning through adequate resource provision, functional machine layout, routine maintenance, and staff training further improves performance. The significant differences observed among managers, supervisors, and machine operators indicate varying perceptions of planning and organization, highlighting the need for better coordination. Overall, modernization, sustainable forest management, and efficient

planning and organization are essential for optimizing wood waste generation and supporting sustainable particleboard production.

Recommendations

Based on the findings of the study, the following recommendations are made.

1. Government should enforce the law on deforestation to facilitate tree growth for particle board production.
2. Government should intensify efforts on public enlightenment on the effects of deforestation since wood contributes greatly for generating income for the nation
3. The sawmill owners should organize training for the staff on effective use of woodworking machines, handling of tools and its maintenance annually for enhancing wood waste generation.
4. There is a need for procurement of modern equipment to enhance efficiency and carry out woodworking operations with minimum effort.
5. Sawmill managers should ensure effective planning of sawmill industries so that woodworking operations can be easily carried out which can lead to more wood waste generation.

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