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Mainstreaming Innovation in The Use of Secondary Raw Materials: A Case study Of Sawmill Waste In Akure, Ondo State

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Abstract: In mainstreaming innovation as technopreneurs in the use of secondary raw materials, selected sawmills in Akure Ondo state was evaluated. These sawmill waste can be turned into useful materials for goods and services by technopreneurs who are proactive and innovative in meeting the need of the market. These are products of lignocelluloses wood materials and they come as bark, rough, cut-off chips, and sawdust. It was observed that sawdust is the most abundant of these materials. The study was done using a questionnaire, personal interviews, on-the-spot assessment, and participatory approaches. Ten (10) sawmills were randomly selected for the study. The study revealed that approximately 749.667kg (0.74966 tons) of sawdust is generated daily in a small-medium scale sawmill. A heap of approximately 5335.2344 tons was generated by a large scale sawmill in the study area in less than 30 days.
As technopreneurs, this raw material was identified and studied with a conclusion that a huge amount of sustainable resources are lying unutilized and further steps must be taken so as to turn waste management and recycling into raw material management. Sawdust can serve as raw material to fill the energy supply gap in Nigeria in an eco-friendly manner and in a distributed form as mini-grids.

Keywords: Technopreneurs; Secondary Raw Materials; Mainstreaming Innovation.

1. INTRODUCTION

The world population has grown from 1 billion in 1800 to 7.6167 billion in 2018, it is estimated that by mid 2030 we will have 8.6 billion people in the world [Wikipedia ,2018]. The amount of consumption of raw materials has greatly increased per person, especially in the developed countries with rapid economic growth . This has come mostly from increased productivity, and through greater use of scare natural resources. Nations with rapid population and economic growth end up with low standard of living due to the increasing scarcity and rising cost of natural resources. In coping with securing prosperity, economic development and the sustainable use of natural resources considering the present growth rate, creation of secondary raw materials and the transformation of waste to value come handy as the way forward.

Waste generation is influenced by the level of economic development, population demographics, industrialisation, public habits and local climate [Njoku *et al*., 2015; Srivastava, 2014]. Waste is generated from various sources and if not managed properly it could have detrimental impact on the environment and society [Ogunwusi 2014; Okedere *et al*., 2017; Owoyemi *et al*., 2016; Akhator *et al*., 2017]. Waste management practices which involve reduce, reuse and recycling of the waste [Owoyemi *et al*., 2016] is presently not sufficient in making the environment free from the impact of waste [Lai & Reddy, 2005].
Creation of secondary raw materials which involves an innovative transformation of various forms of waste to wealth by value addition also plays an important role in conserving the environment. Technopreneurs must ensure that innovation is brought into play in every stage of the process through the content, the process and the process skills [Okorie *et al*., 2015]. It will require technopreneurs to first identify and have a good data basis for these secondary materials sources, the detection systems, determine a specific material flow management, product design, the separation and processing needed, the recycling technologies and eco-balance involved and finally the legislative logistic that is needed to innovatively transform these waste into raw materials [FONA, 2018].
With continuous research and development in the field of science and technology, technopreneurs have achieved new technologies for developing alternative products which will be useful to society [Lai & Reddy, 2005; Oladeji, 2011; Ogunwusi 2014; Simonyan and Fasina, 2013; Okedere *et al*., 2017; Akhator *et al*., 2017]. Advancement in Lignocellulose biomass conversion technologies especially gasification and pyrolysis is such that materials which could have been classified as waste are serving as resources for energy production [Oladeji, 2011; Diji 2013; Ogunwusi 2014; Owoyemi *et al*., 2016; Okedere *et al*., 2017]. Traditional biomass (wood fuel and charcoal) accounted for about 80 - 85% of total

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energy consumption which has contributed to desertification, deforestation and erosion in the country [Ogunwusi 2014; Owoyemi *et al*., 2016]. This high percent share of biomass represents its use to meet off-grid heating and cooking, mainly in rural areas and by the urban poor. To meet such high energy demand in Nigeria in an environmentally friendly manner such that deforestation is reduced, biomass waste utilisation must take the centre stage [Ogunwusi 2014; Akhator *et al*., 2017; Okedere *et al*., 2017].

In Nigeria, particularly in some southern state like Ondo, Cross River, Ogun, Edo,Delta, Ekiti, Osun and Oyo, we are blessed with high forest zones with abundant wood supply. [Bello & Mijinyawa,2010; Akhator *et al*., 2017]. This forest area accounts for 11.3% the total available agricultural land which is estimated at 74.5 million hectares of the total land area [Simonyan & Fasina, 2013]. Sawmill industry in Nigeria account for 93.32% of the total number of wood based industries [Fuwape,1989 ; Ogunwusi 2014; Akhator *et al*., 2017]. It is characterised majorly by small scale and medium scale operators that settle in clusters [Olufemi *et.al,* 2012]. The saw millers typically fell timber from the forest, transport them to their mills and saw the timber into lumber of various dimensions. In the process, saw dust and other wood waste such as wood bark, slab, log-ends etc. are produced. Nigeria has an estimated wood waste generation of about 1,000,000m^3 annually between 2009 and 2010[Sambo 2009; Ogunwusi 2014; Owoyemi *et al*., 2016] with sawdust amounting to about 1.8 million tons annually (4931.51 tons per day) [Sambo 2009; Ohimain 2011; Owoyemi *et al*., 2016; Akhator *et al*., 2017]. Owoyemi *et al*., 2016 gave an estimate for 2014 wood waste generation in Nigeria as 104,000 m^3 daily and Okedere in 2016 estimated the total quantity of sawdust generated in the southwestern region of Nigeria annually as 526,650 metric tonnes [Okedere *et al*., 2017].

In Akure, Ondo state, Nigeria, there are many sawmills owned and operated by small and medium scale entrepreneurs [Olufemi *et al.,* 2012; Ogunbode et al., 2013; Okedere *et al.*,2017]. There has been a significant increase in the number of sawmills operating in Ondo state. A report by the Ondo state Department of Forestry (2007) gave the number of registered sawmill as 311[Olufemi et al., 2012]. Presently, a visit to the Department of Forestry Exploitation and Utilisation in 2016 revealed that this has grown to about 576 registered sawmills in Ondo state, Nigeria. The waste generated by their operations is becoming a serious environmental and health issue even to the saw millers them self [Okedere *et al.*,2017]. With daily clearing and disposal of these residue (waste) as domestic firewood and the like, the waste abound, especially the sawdust which they dump and openly burn causing great pollution. To help achieve the aim of the study which is to have a firsthand account of the extent of waste generation and how to turn waste management and recycling into material management for energy generation in sawmills located in Akure, the following specific objective were set;

- To identify the major type of waste and the average amount generated in sawmills.
- To identify the method of waste disposal and conversion available.
- To identify the best method of introducing research and development in converting this waste thus achieving a win – win situation in waste management problem, raw material scarcity and energy problem in the nation .

2. MATERIALS AND METHODS

2.1. Study Area Description

The research was conducted in Akure metropolis in Ondo state, southwestern Nigeria. From the field study, it was gathered that sawmill and sawmill clusters are grouped in zones across the state. This influenced the scope for the ten (10) sawmills randomly selected for study as shown in Table 1. The study area is located within the sub-equatorial region characterized by a tropical monsoon climate. As at march 2018, the population of the study area (Akure North and Akure South) with a growth rate of 2.5% is projected to be 486,311 and 177,624 persons respectively.

3 RESEARCH METHODOLOGY

A descriptive survey research method was adopted for the study [Akinnubi 2015]. The data collection methods employed include on-the-spot assessment according to Robson [1993] as stated by Bello and Mijinyawa [2010]. For physical inspection of the sawmill waste, a structured questionnaire [Akinnubi 2015], personal interviews and participatory approach as reported by Ogunbode et al., 2013 were used. A random sampling of ten (10) sawmills in the study area were done using this research method. About 100 questionnaires were distributed and 60 respondents returned their copies. The respondents were made up of sawmill workers, machine operators, timber drivers, woodworkers around the area. Purposeful sampling was done using particular sawmills due to proximity, availability of work and logistics. A thirty (30) days study was done to quantify the amount of waste generated in one month in an average small-medium scale sawmill. In the large scale sawmill found the study area heaps of their waste generated in less than thirty days was measured. The returned questionnaire was used for analysis and the data collected was also analyzed and reported as percentages and frequencies tables.

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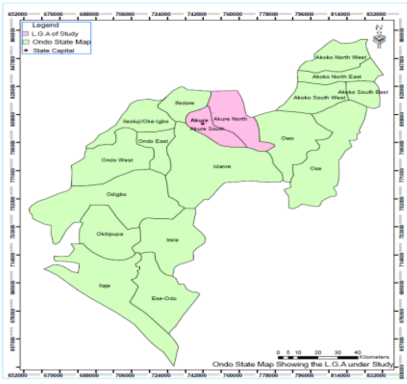
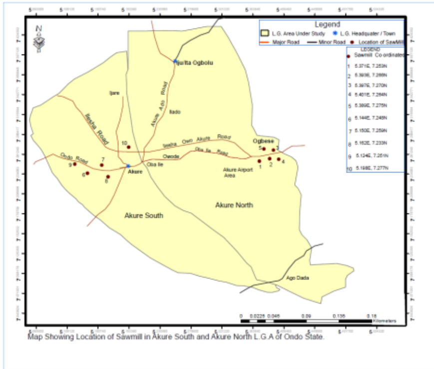
Figure 1. Map of Ondo State showing the study Area.





3. RESULTS AND DISCUSSION

From the field study involving personal interviews in the selected area, An average of ten to twenty (10 – 20) logs of wood is sawn each day depending on the size of each log (Table 1). The classification of wood species were done by the saw millers into hardwood and Softwood (white wood) considering ease of sawing, with the most available species such as Afara (*Terminalia superb),* Oporoporo (*Pterygota macrocarpa)* and ,Ita white(*Cetis Africana)* .The major Challenges observed in the sawmill were grouped into four as shown in Table 2, 100% (n =10) of the sawmills ticked energy (power) as their major challenge, followed by environment (waste) which is 80% (n =8) and only 2 each of the 10 sawmills studied considered economy and engineering (technology) (n=2) 20% as a major challenge.
The management of waste generated in the sawmill as shown in Table 2 and Plate 2, showed that the wood residue considered as waste comprises of sawdust, rough wood, slab and wood bark. As was observed, sawdust is the major waste issue demanding attention. Some of the respondent believed sawdust is the only waste available as other residues are easily sold off as firewood, poultry materials, medicine and so on. About 100% of the sawmill do opening air burning of these sawdust. None of the sawmill visited could give an estimate of their daily waste generation. The thirty (30) days on-site study for the estimation of waste generated daily as shown in Table 5 and Plate 3, gave an average of (42 bags) 749.667 kg of waste generated daily in a medium size sawmill. It was observed that such large amount of sawdust waste is generated daily by most sawmills and these wastes are daily packed in bags or basins as the case may be and dumped for open burning.

Plates 4 shows a heap of sawdust as seen in a large scale sawmill in the study area generated in less than 30 days. This was measured as shown a height of 6.5m, a width of 12,5m and a breadth of 15.8m. Relating the volume of the heap to the density of wood, we have approximately 5,335,234.375kg (5335.2344 tonnes). This study also revealed that different wood species generate different volumes of sawdust with the less dense species generating higher volumes of sawdust. This agrees with the study done by kukogho and others as stated by Ogunwusi, 2004. Again, the amount of work in each day which is a function of power and some technical issues, in turn influences the volume of sawdust generated each day. This was obviously seen from the different number of bags packed each day for the thirty (30) days of study.

The health and safety aspect of their operation in general is not taken serious even when they are aware of the impending dangers. The respondent acknowledged the offensive odour and the possibility of chemical emissions from the sawdust dump especially when it rains.

The sawmill operators and some of the timber drivers during the participatory interview agreed that wood waste abound even more in the forest. These waste come as off cuts, rooted stump, and abandoned felling. This agrees with FAO, [2001] that about 60% of the total harvested timber is left in the forest to rot. They are looking forward to better ways of converting these wastes considering the extent of the challenge posed by the waste. From Table 4 the major people they know that come for their waste are those using it for domestic purposes and their percentage is small relative to the rate of waste generation. The respondents admitted that there is a need for researchers to introduce them to better and more profiting way of managing and converting their waste.

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Table 1: Waste Management

Name of Sawmills	Nature of Waste	Major Waste	Method of Disposal/ Management	Quantity of Waste generated	No of logs per day	Frequency of Removal
Adegoke	Barks, rough wood, Sawdust	Sawdust	Open air burning	Large	20	Daily
Constant	Fire wood, Bark,Slab, Sawdust	Sawdust	Burning	Large	15	Daily
Chika	Rough wood, Sawdust,bark	Sawdust	Open air burning	Large	10	Daily
Acro	Sawdust, Bark, rough wood, fire wood, slab	Sawdust	Open air burning	Large	50	Daily
Divine Grace	Bark, rough wood, sawdust, slab	Sawdust	Open air burning	Large	15	Daily
First blow link logistics	Bark, rough wood, fire wood, slab	Sawdust	Open air burning	Large	20	Daily
Usman (means)	Fire wood, Slab, barksSawdust	Sawdust	Open air burning	Large	25	Daily
Ibitoye	Sawdust, rough wood	Sawdust	Open air burning	Large	15	Daily
Iya ayo	Bark, rough wood, fire wood, slab	Sawdust	Open air burning	Large	10	Daily
Akin	Fire wood, Slab,barks, sawdust	Sawdust	Open air burning	Large	20	Daily

Authors' field work (2016)

Table2: Major Sawmill Challenges

Challenges	Frequency		Percentage (%)	
	Yes	No		
Economic	2	8	20	80
Energy (power)	10	0	100	Nil
Engineering (Technology)	2	8	20	80
Environmental(Waste)	8	2	80	20
	n= 10			

Authors' field work (2016)

Table 3: Estimation of Average waste generated

Day	No of bags	Average Waste (kg)
1	24	432
2	28	504
3	42	756
4	34	612
5	46	828
6	42	756
7	45	810
8	33	594
9	105	1890
10	55	990
11	43	774
13	24	432
14	26	468
15	28	504
16	38	684
17	61	1098

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18	26	468
19	37	666
20	65	1170
21	42	756
22	28	504
23	55	990
24	45	810
25	100	1800
26	43	774
27	38	674
28	29	522
29	46	828
30	22	396
	Total =22490 kg of Waste	

Note **:** Average size of a bag =18kg
In a month (30 days) we have averagely 22490kg (22.49 tons) of waste then in one (1) day, we have approximately 749.667 kg (0.74966 tons) and 42 bags per day. (Authors' field work ,2016)

Average Estimate of sawdust heap from a large scale sawmill (plate 4)
Mass = 5335234.375kg (5,335.2344 tonnes)

Table 4: Waste Treatment /Conversion

Conversion Method	Frequency(n=10)	Percentage (%)
Open air burning	7	**70**
Particle board	0	**0**
Incineration	1	**10**
Pyrolysis /Gasification	0	**0**
Domestic Purposes	2	**20**
	10	**100%**

Authors' field work (2016)

4. CONCLUSION AND RECOMMENDATION

There is great opportunity of creating wealth from waste in the sawmill industry. Huge amount of wood waste is generated daily in Akure and the management of these wastes is a serious environmental and health issue as identified by the research study. From the study conducted, we conclude, that there is an urgent need for an innovative method of handling these waste and turning it into raw materials for other processes in an environmentally friendly manner. All these cannot be achieved without the involvement and networking of various stake holders like the government, the researchers and the academia, environmental/ health and safety officers, forestry department and the saw millers such that an innovative logistics and technical solution in the collection, transportation sorting and ultimate conversion of the sawmill waste into raw materials of great value.

We recommend that ;

1.) Health and Environmental safety policies must be enforced in sawmills with proper sensitisation by all stakeholders.
2.) Open air burning of wood waste must be discouraged and where burning is inevitable, it must be done in an incinerator.
3.) Research has shown that utilisation of wood residue for direct electricity is feasible and serious steps must be taken in this direction.
4.) Solid fuels such as pellets and briquettes made from sawdust which could be used in eco-friendly stoves should be considered,
5.) One of the promising techniques used for converting these waste to useful and profitable product gas is gasification.
6.) Having confirmed the huge availability of sawdust, gasification designs should be done to handle sawdust as fuel feedstock for power generation in form of mini grids which could be used even in small clusters.

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Appendice

Plate 2: Waste Types

Plate 3: Average daily dump in small-medium scale sawmill.

Plate 4: Heap of sawdust from a large scale sawmill

Plate 5: Dump sites for Opening burning.

REFERENCES

[1]. Akhator P.,Obanor A., Ugege (2017) "Nigeria Wood Waste : A Potential Resource for Economic Development" Journal of Applied Science and Environmental Management Vol. 21 (2) 246 -251.
[2]. Akinnubi Caroline Fumbi (2015) "Influence of Sawmill Industries on the Health of Sawmill workers and of the Environment in Ondo State, Nigeria" Journal of Education and Social Research MCSER publishing, Rome-Italy" Vol. 5 No.2
[3]. Arowosoge O.G.E., (2015) "Survey of Wood Species Utilized for Roofing in South- Western Nigeria" International Journal of Applied Science and Technology. Vol. 5,No. 4; pg 94- 102.
[4]. Ayeni A (2011). Malaria Morbidity in Akure, Southwest, Nigeria: A Temporal Observation in a Climate Change Scenario. Trends in Appl. Sci. Res. 6: 488-494.
[5]. Bello Segun R. and Mijinyawa Y. (2010) "Assessment of Injuries in Small Scale Sawmill Industry of South Western Nigeria". Agricultural Engineering International: the CIGR Journal of Scientific Research and Development. Manuscript 1558. Vol. XII.
[6]. Bhavanam A. and Sastry R. C., (2011), "Biomass Gasification Process in Downdraft Fixed Bed Reactor: A Review, International Journal of Chemical Engineering and Application. Vol. 2, No. 6. Pg 425- 433.
[7]. Bianatta, WEE Recycling "Use of Raw Materials and Economic Development" https:// www.vianatt.gr/contents - en .asp? id =93 Sourced October 2018.
[8]. Douglas M. and Ling O., (1999) "Industialising Cities and the Environment in Pacific Asia" Toward a Policy Framework and Agenda for Action. United States –Asia Environmental Partnership Framing Paper; pg 1-73.
[9]. FAO (2001), "Global Forest Assessment". FAO publication. FAO Rome.
[10]. FRNOG. (2009) Legal notice on publication of 2006 census final results. *Federal Republic of Nigeria Official Gazette*, *96*, B1–42.
[11]. Fuwape J. A. (1989) "An assessment of wood efficiency in some sawmills in Ondo State. Nigeria Journal of Forestry. 20(2) ; 44-48.
[12]. Lai Banwari and Reddy MRVP (2005), Wealth from Waste; Trends and Technologies. Second edition, Energy and Resource Institute. Pg vii,1-25, ISBN 81-7993-067-X
[13]. Ndukwe N. A, Jenmi F.O., Okiei W. O. and Alo B. I. (2009) "Comparative Study of Percentage yield of Various Nigeria Wood species using the Kraft Process" African Journal of Environmental Science and Technology Vol. 3 (1) pp. 021 - 025.

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[14]. Njoku N., Lamond J., Everrett G. and Manu P. (2015) "An overview of Municipal Solid Waste Management in Developing and Developed Economics: Analysis of Practices and Contributions to urban flooding in sub- sharan Africa. 12th International Postgraduate Research Conference Proceedings Manchester, Uk pp 200 -212.
[15]. Ogunbode ,E.B., Fabunmi F. O., Ibrahim S.M., Jimoh I. O. And Idowu O. O. (2013) "Management of Sawmill waste in Nigeria: Case of Minna, Niger State. Greener Journal of Science ,Engineering and Technology Research. Vol. 3 (2), pp.034-041.
[16]. Ogunwusi A. A. (2014) "Wood Waste Generation in the Forest Industry in Nigeria and Prospects for Its Industrial Utilization" Civil and Environmental Research. Vol 6, No9 pp. 62 -69.
[17]. Okedere O. B., Fakinle B. S. Sonibare J. A., Elehiafe F. B., and Adesina O. A., (2017) " Particulate Matter Pollution from Open burning of Sawdust in Southwestern Nigeria" Cogent Environment Science ,3 :1367112.
[18]. Okorie N N, Kwa D Y, Olusunle S.O.O. & Akinyanmi A.O,(2015) " Technopreneurship in the Material World: A Fulcrum for Industrial Development in an Emerging Economy" presented at the Eleventh Biennial Conference on Entrepreneurship, at Entrepreneurship Development Institute of India, Ahmedabad February 18-20, 2015 .
[19]. Olaoluwa A. I., Samson A. S., Mubi K. H., Ogbole J., Alaga A.T., and Ajayi V.,(2016) "Urban Growth Analysis In Akure Metropolis". International Journal of Scientific &Technology Research Volume 5, Issue 04.
[20]. Owoyemi J. M., Zakariaya H. O., Elegbede I. O., (2016) "Sustainable Wood Waste Management in Management in Nigeria" Environmental and Socio – economic studies 4, 3: 1- 9.
[21]. Oladeji John Taiwo (2011) "Agricultural and Forestry Waste and Opportunities for their use as an Energy Source in Nigeria –An Overview" .World Rural Observations, 3 (3)
[22]. Olufemi B., Akindeni J. O., Olaniran S. O. (2012) "Lumber Recovery Efficiency among Selected Sawmills in Akure, Nigeria. Drvna Industrija 63 (1) 15 -18.
[23]. Oyedepo S.O., (2012) "Energy and Sustainable Development in Nigeria: the way forward. Energy Sustainablility and Society 2:15
[24]. Sambo A. S. (2009) "The Place of Renewable Energy in the Nigeria Energy Sector" Workshop on Renewable Energy Polices October 2009, Addis Abba Ethiopia.
[25]. Segun R. Bello and Yahaya Mijinyawa (2010) "Assessment of Injuries in Small Scale Sawmill Industry of South Western Nigeria". Agricultural Engineering International: the CIGR Journal of Scientific Research and Development. Manuscript 1558. Vol XII.
[26]. Sensi Seed B.V (NC) https :/sensiseeds.com /en/blog/Cannabaceae-family. "The Cannabaceae Family – Sensi Seeds". Sourced 17 July 2017.
[27]. Simonyan K. J. and Fasina O.(2013) " Biomass Resources and Bioenergy Potentials in Nigeria' African Journal of Agricultural Research, Vol. 8(40), pp. 4975-4989.
[28]. Srivastava V., Ismail S.A., Singh P. And Sing R.P., (2014) "Urban Solid Waste Management in the Developing world with emphasis on India" Challenges and Opportunities. Reviews in Environmental Science and Bio/Technology pg 1-20

[29]. World Bank Group [US] "Waste Development " Urban Series – Knowledge Papers https:/ site resources. World bank .org/ INTURBANDEVELOPMENT/Resources/336387 -1334852610766/chap3. pdf Sourced: October 2018.
[30]. World Population – Wikipeadia https://en,wikipedia.org/wiki/world_population. Sourced October 2018
[31]. Population growth https://en,wikipedia.org/wiki/population_ growth. Sourced October 2018