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Review Article

Pollution from timber processing industries in Nigeria: challenge and adaptive measures

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ABSTRACT

Production industries process raw materials (input) and generate by-products (residues) of various forms. One of the major challenges of industrial sectors in Nigeria is pollution resulting from improperly managed and indiscriminately disposed residues. Noise produced from the use of heavy industrial machines is another major source of pollution from industrial processes. The timber industry is among the production industries in Nigeria that is renowned for its great contribution to the economy's Gross Domestic Product (GDP). However, throughout the wood supply chain-from sawmills to final products, the wood products manufacturing industry is a potential source of environmental pollution. This paper examines viable adaptive measures in the management of air, land, noise, and water pollution with a view to addressing the challenges of environmental pollution. During sawmilling procedures, huge biomass is generated into residues (sawdust, shavings, trimmings, edgings, and so on), noise is produced from mechanical processes, and particulates are released as byproducts of fossil fuel combustion from machines and power-generating sets. In Nigeria, large volumes of residues or byproducts are indiscriminately disposed of (or improperly managed) in most timber processing industries. It is noteworthy that environmental pollution is among the challenges with far-reaching harmful effects on Nigerian citizens. And could lead to pollution-related problems, including flooding, disease outbreaks, pandemics, health hazards, and death. The identified pollution-related challenges from timber industries in Nigeria and their associated consequences can be drastically reduced if conscious efforts are put in place. Hence, this study recommended the reconstitution of timber residues.

K E Y W O R D S : *Agro-allied, Nigeria, Petrochemical, Sawdust*

INTRODUCTION

From time immemorial, and up till date, the importance of utilising wood-based products cannot be overemphasized. Timber processing and wood products manufacturing industries are among the major industrial sectors in Nigeria (Ogunwusi, 2019). Wooden products or wood-based items are used in homes, offices, markets, churches, mosques, recreation centres, and other social gathering both locally and globally. Among the major wood products used for domestic and industrial applications are kitchen cabinet, wardrobe, flower vase and stool (Plate 1). Some of these items have been replaced by alternative products such as metals, plastic and steel. However, due to its versatility and strength properties, wood and wood products are still commonplace in the structural and construction industry (Leicester, 2001).

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a b c d



Plate 1: Kitchen cabinet (a); Wardrobe (b); Flower vase (c) and Stool (d)
Source: https://www.carbonlimitsngr.com/projects/biomass-project/

FAO (2001) predicted that by the end of 2020**,** global consumption of industrial timber products will increase by 45%. The global timber consumption in 2020 will be 2.3 billion cubic meters. This is an increase of 24% from the 2015 level and equivalent to a 4.4% increase per annum. Moreover, the World Bank has forecasted that global timber demand is set to quadruple by 2050 (FIM, 2017). Hence, the global timber sector is facing the dual challenges of meeting the growing demand for timber products and minimizing associated environmental pollution emanating from timber processing and wood products manufacturing (FAO, 2001). According to Adhikari & Ozarska (2018) timber products manufacturing, from log extraction to final products, involves several stages which can affect the surrounding environments in the form of land-, noise, air-and water pollution. However, sawmill is one of the major sectors in the timber processing and wood products manufacturing industries (Ohagwu & Ugwuishiwu 2011).

Ogunwusi (2019) reported that the number of sawmills operating in Nigeria in the year 2010 was about 1325. However, despite the production capacity, Okedere *et al*. (2017) estimated the wood waste generation in Nigerian sawmills between 2009 and 2010, to be about 1,000,000m^3 annually with sawdust amounting to about 1.8 million tons annually; that is, about 4931.51 tons per day (Sambo 2009; Ohimain 2011; Owoyemi *et al*., 2016; Akhator *et al*., 2017). Owoyemi *et al*., 2016 gave an estimate of wood waste generation in Nigeria in the year 2014 as 104,000 m^3 daily. According to Okedere *et al*. (2017) and Okorie (2021) the estimated total quantity of sawdust generated in the southwestern region of Nigeria in 2016 was 526,650 metric tons. Unfortunately, unsustainable management (or indiscriminate disposal) of these sawmilling wood residues generated in sawmills is constituting menace (land-, and water pollution) to the environment.

About 93.32% of air pollution from wood processing industries comes from sawmill activities. More so, noise pollution has been recognized as common environmental challenges associated with sawmilling operations in Nigeria. This has been attributed to poor technological knowhow, use of substandard or faulty machines, failure to comply with standard working operations. According to Omole *et al*. (2018); Tobin *et al*. (2016); Adeoye *et al*. (2015); Adeoye *et al*., (2014); Aderibigbe (2010), menace of pollution among Nigerian sawmills are associated with a number of short comings ranging from the poor political will to implement comprehensive health care policy, little knowledge of occupational hazards, higher rates of unqualified safety inspectors, meager funding, and poor infrastructure, poor integrated production system, poor execution or failure to enact law relating to pollution control and improper waste disposing procedures. This paper examines the menace of pollution emerging from timber processing and wood products manufacturing industries- a case study of sawmills in Nigeria, with focus on potential ways to minimize these environmental impacts as adaptive measures in timber industries.

Air pollution from sawmills in Nigeria: Sources and Cases

Air pollution is the contamination of air or atmosphere by strange materials which are introduced or released directly or indirectly. According to Adeoye *et al*. (2014); OECD (2020); Akindele *et al*. (2022), Orru *et al*. (2022), The Guardian Nigeria (2022) & Atkinson (2024), air pollutants range from smoke to particles. Smoke is either discharged from exhausts of heavy machines or in cases where wood residues on landfill sites are burnt, smokes are produced; hence, emissions of greenhouse gases contaminate the environment (Ijaware and Adefisoye, 2024).

Greenhouse gases (carbon monoxide, carbon dioxide, unburned hydrocarbon, particulate matter, sulfur dioxide and nitrogen oxides) are byproducts of fossil fuel combustion while air-suspended wood particles are generated from wood dust during operations such as sanding (Adeoye *et al*., 2014 and Orru *et al*. (2022). When the aforementioned pollutants contaminate the air, they are inhaled or absorbed into the human system with associated health challenges. Considering the consistent and alarming rise in rate of air pollution worldwide, especially in low- and middle-income countries, cases of air pollution in Nigeria-based sawmills may grow much larger in the years to come (Raimi *et al*., 2020).

Airborne wood dust is the most prevalent occupational exposure hazard in the wood industry (Orru *et al*., 2022). Wood dust inhalation has been associated with upper and lower respiratory symptoms in humans including cough, wheezing, sputum production and shortness of breath (Edith and Edmund, 2012; Raimi *et al*., 2020). Syndromes that may arise include mucus membrane irritation syndrome, extrinsic allergic alveolitis, organic dust toxic syndrome, occupational asthma, non-asthmatic chronic airflow obstruction, simple chronic bronchitis (mucus hypersecretion), cryptogenic fibrosing alveolitis, adenocarcinoma of the nasal and paranasal sinuses, cancer of the larynx and pharynx. Ill-health from wood dust inhalation results in the inability of the worker to meet the demands of his job, increased incidences of sickness absenteeism and eventually early retirement (Ige, and Onadeko, 2000).



Plate 2: Combustion of sawdust on landfill (land and air pollution)
Source: https://www.carbonlimitsngr.com/projects/biomass-project/

Noise pollution from timber processing industries in Nigeria: Cases and Consequences

Timber processing and wood products manufacturing involves different types of processes which include sawing, drying, sanding, jointing, gluing, finishing and so on. Often times, the aforementioned processes involve the use of heavy industrial machines which contribute to noise pollution. According to Chinniah (2016) mechanical processes such as sawing, crushing, sanding are potential sources of noise pollution. The low level of technical knowhow, failure to adhere to manufacture's prescription for machine operations, inefficient power supply, use of faulty and old machines, failure to use safety kits are among the factors that contributes to, or worsen noise pollution in sawmill industries in Nigeria (Rathipe & Raphela, 2022; Hemmat *et al.*, 2023; Eziri *et al.*, 2023).

According to Adedeji *et al*. (2019) the menace of noise pollution in the sawmilling industries is a leading challenge of environmental concern. Noise pollution is among factors contributing to noise interference with speech communication, reduction in working efficiency, undesirable physiological changes in heart beat rate, inducement of blood pressure and psychological distress as well as affects on auditory perception. Noise induced hearing loss can result into sensor neural hearing loss, cochlear damage or other acoustic trauma (Lapsley *et al*., 2006, Marshall et al., 2009).

Land and water pollution from sawmills in Nigeria: Sources and Cases

It is no doubt that land and water pollution are commonplace in Nigeria. Huge residues (in the form of sawdust, shaving edgings, and trimmings) which are generated during timber processing (Plate 2) are indiscriminately disposed on landfill sites and water bodies. Thus, unsustainable management of residues in Nigerian-based sawmills have been reported to consistently constitute environmental menace. According to The Guardian (2023) indiscriminate dumping of wood residues in water ways, streams, landfills is recognized among factors contributing to natural disaster (such as flooding) in Nigeria.

Implications: Consequences of pollution from sawmills

Air-borne diseases and other related health challenges: air-borne diseases and infections are potential challenges of air pollution. The World Health Organisation estimates that only 1 in 10 people globally live in areas where air pollution is below recommended levels and that air pollution is responsible for 7 million deaths a year – one in eight deaths globally. Air pollution dominates all other major avoidable causes of death including road accidents, tobacco smoking, alcohol use, and transmissible diseases such as malaria, AIDS, and tuberculosis. Air pollution represents a major threat to human health in the 21st century (OECD, 2020).

According to Adeoye et al. (2014) greatest air pollution problem in the Nigerian environment is atmospheric dust that arises from many industrial processes including sawmill industries. Studies (Fatusi and Erhabor, 1996; Ige and Onadeko, 2000; Edith and Edmund, 2012) have shown that exposure of timber industrial workers to environmental pollutants (such as wood dust) increases the incidence of respiratory diseases. High prevalence of respiratory symptoms, increased nose and eye irritations, skin symptoms, and high prevalence of allergy/sensitivity symptoms were observed among workers exposed to wood dust compared to unexposed. Cancer has also been associated with exposure to wood dust. The National Institute for Occupational Safety and Health considers dust from both hardwood and softwood as potentially carcinogenic to humans (USDLOSHA, 2008).

Water-borne diseases: Spread of water borne diseases and its adverse effects

Contamination of water is a prevalent occurrence in coastal areas or among neighboring communities who depend on available streams, river or water bodies for their water supply. This is a common phenomenon among settlements in some rural dwellers in Nigeria. As a result of water contamination from wood dust chemicals, rural dwellers who live around sawmilling industries are sometimes easily predisposed or vulnerable to water borne disease which sometimes may lead to a communicable disease among the rural dwellers. Among the possible waterborne diseases which could be attributed to wood wastes contamination in Nigeria are cholera, Dracunculiasis, Hepatitis, and Typhoid (Nwabor *et al*., 2016). Contamination by chemical pollutants in drinking water have also been linked to a wide range of negative health impacts, including cancer, cardiovascular illness, neurological disease, and miscarriages (Shayo *et al*., 2023).

Reduced Life Span (Death): As a result of exposure to some of the diseases or infection caused by any of the aforementioned pollution emerging from sawmilling industries, infected persons battle with ailment which sometimes result into incurable sicknesses, acute cases, deterioration of life span (Ige and Onadeko, 2000; Nwabor *et al.*, 2016; Raimi *et al.*, 2020). Ultimately, such ill-health degenerate until infected person dies. Generally respiratory health effects have been documented in workers exposed to a variety of wood dusts and reduced lung function is said to be associated with increased illness and mortality (Ige and Onadeko, 2000).

Threats to aquatic life: Discharge of effluents and solid wastes into rivers, streams, lake, and so on has been recognized to be a serious menace to aquatic life. The siting and operations of sawmills impact negatively on the environment in several ways; pollution of water bodies, destruction of breeding grounds for fishes and other aquatic organisms such as mudskippers, snakes, crabs, and other reptiles; destruction of mangrove (Igben, 2019). Fishes and other aquatic animals die in hundreds or thousands as a result of contaminated water bodies or poisoning of water by wood chemicals. The resultant effect could be loss of biodiversity, bankruptcy, fish farm failure, threat to certain aquatic species or human community living around coastal area (Adeoye *et al*., 2014).

Flood disaster: Flood disaster is one of the regular natural disaster which frequently ravage man and his environment. A case study is Nigeria, a developing country with poor and unsustainable wastes management policies. Indiscriminate disposal of residues is among the factors causing several cases of flood disaster that have ever been reported. The consequences are often felt on buildings, farmland, trees, rivers, automobiles and human environments. (Ikiriko & Gbarabe, 2024, NEMA, 2024; UNDP, 2024).

Adaptive measures:

Recycling (reconstitution) of residues for production of engineered wood products: Reconstitution of wood residues (such sawdust, planer shavings, slabs, edgings) to produce value-added products is a viable technology in the wood products industries. Production of engineered wood products from sawmill residues has been reported in several countries all over the world.

Individual particles in reconstituted products generally minimizes the negative effects of anisotropy and hygroscopicity exhibited by larger pieces of wood as the materials are distributed more or less randomly to form composite or laminated products. Production of wood-based composites such as particleboard, cement-bonded board (Plate 3), plastic-bonded boards and glulaminated products have the potentials of reducing the menace of land pollution suppose wood residues are sustainably utilized for production of reconstituted wood products (Ohagwu and Ugwuishiwu, 2011; Adhikari and Ozarska; Balboni, *et. al*., 2023, Rawat, 2023).



Plate 3: Wood-cement Ceiling boards.
Source: Forestry Research Institute of Nigeria.

Wood composites, briquettes and glulaminated products (Plate 4) are among the common reconstituted wood products which have been reported as breakthrough in the wood industries (Lela *et al*., 2016; Balboni, *et. al*., 2023, Rawat, 2023).

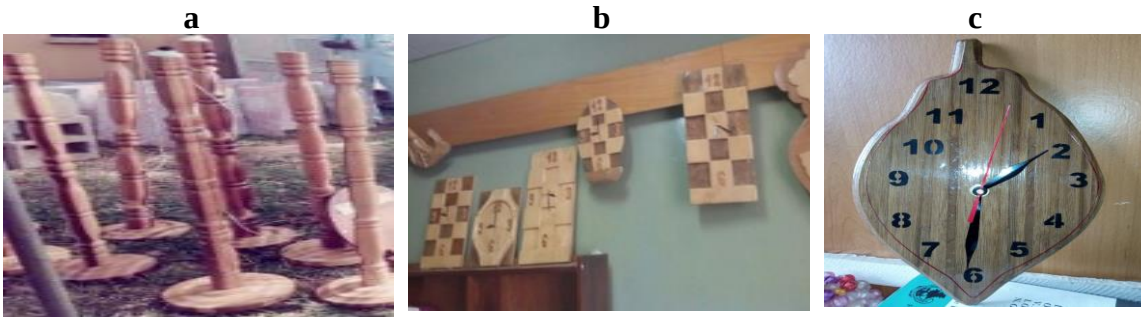

Plate 4: Glulaminated products: cross section of products (a); various laminated wall clock (b) and single wall clock (c) Source: Forestry Researchh Institute of Nigeria

Adoption of renewable natural energy sources for sustainable energy nexus: renewable energy has been known to address the menace of fossil fuel combustion. One of the renewable natural energy sources which has been recognized globally is solar energy. Solar energy has been recognized as a viable, adaptable and environmentally friendly energy source. According to IIED (2012) solar energy can be adopted for several industrial uses with outstanding results. Collaborations and innovation driven by international initiatives have resulted in exponential growth for industrial operations in developing countries, among which Nigeria has a great potential. Significant investment in solar energy other renewable energy technology for wood products industry such as sawmill is a viable alternative which reduces pollution from fossil fuel combustion in industrial machines (Ohagwu & gwuishiwu, 2011).

Incorporation of industrial integrated systems:

Industrial integrated systems involve integration or incorporation of several industrial processes in a systematic way. The industrial processes are related, compactible and form a nexus. Residues generated from sawmilling processes have been integrated into other industrial production such as in the agro-allied industries. According to Dudziec *et al.* (2022) sawmill residues are used in the power industry, where it accounts for the greatest portion of solid biomass used in combined heat and power plants and heat-generating plants, mainly as chips. A multi-distributed generation (multi-DG) systems designed based on utilization of sawdust biomass and other resources such as solar, natural gas and diesel for off-Grid Application typifies the possibility of harnessing saw dust for energy generation (Akinyele *et al.*, 2022).

Utilization of residues (sawdust and shavings) for bedding in poultry litter production (chick and chicken stock) is a commonplace (Villagrá *et al*., 2014; Garcês et *al*., 2014, Teixeira *et al*., 2015). Subsequently, wastes generated from poultry production are sometimes utilized to produce organic manure (or compost) which is useful as fertilizers in crop farming. More so, chicken wastes are useful in fish farming (Das *et al*., 2020; Usman *et al.*, 2020). Instead of indiscriminate disposal of sawmill residues into landfills and water bodies, industrials sectors in Nigeria have the capacity to establish formidable and well-organized industrial integration systems emanating from sawmilling residues. This is a step towards generating commercially viable products, increasing lumber recovery rate and reducing environmental pollution (Rawat *et al*., 2023).

Use of modern equipment, machines and tools

Old gadgets (industrial production machines, equipment and power generating sets) with faulty parts consume energy, generate unwanted noise from wear and tear and have tendencies of emitting more pollutants into the atmosphere (Ohagwu and Ugwuishiwu, 2011; Akinyele *et al*., 2022). In developed nations, reduction in air pollution emerging from sawmilling industries have been partly attributed to utilization of up-to-date, standard or modernized machines. Consequently, laws banning or regulating the use of old, faulty machines have been enacted and enforced towards ensuring environmental benign sawmilling processes (Gaussin et al. 2013; Adhikari and Ozarska, (2018).

CONCLUSION AND RECOMMENDATIONS

It is no gainsaying that the sawmilling industries is an integral sector in the timber processing industries in Nigeria. The associated environmental pollution (air-, land, noise-and water pollution) emerging as a result of poor pollution management is of great concern to the Nigerian citizenry. As a way of addressing the environmental pollution and improving the productivity in sawmilling industries in Nigeria, this paper has identified viable adaptive measures in the management of timber residues which include recycling (reconstitution) of residues through production of engineered wood products, adoption of renewable natural energy sources for sustainable energy nexus, incorporation of industrial integrated systems and use of modern equipment, machines and tools

Having considered the various consequences of pollution (air, land water and noise) on human health and his environment, plus adaptive measures in addressing the menace of pollution from sawmilling industries, the following are imperative:

- the Nigerian government should constitution which will favour and encourage industrial integrated systems in Nigeria-based saw mills
- enactment and adoption of stringent environmental regulations on waste generation and management from sawmilling procedures
- establishment of reconstituted wood products industries which will absorb and sustainably utilise wastes generated from wood-based industries-especially, sawmills.
- Workers in wood industries should be orientated on the importance of using safety kits and precautionary gadget,
- substandard and archaic machines should be banned and regular inspection and supervision of sawmilling production should be enhanced.
- Establishment of sawmills should only be approved by the Nigerian government when necessary prerequisites regarding wood residue management have been met.
- In choosing energy sources for timber production processes such as in sawmills, there is need for adoption of renewable energy as a supplement (or if possible, alternative) for fossil fuel-based energy techniques. Even if fossil fuel-based energy source are to be used, efforts must be made to reduce it to the barest minimum.
- Old, substandard and faulty machines (used in sawmilling industries) whose status are indiscriminate contributing to air-or noise pollution should be replaced with environmental friendly ones.

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Authors' Contributions

The literature search, sorting manuscript writing and all necessary financial implication were taken care of by all authors.

Ethical Statement

Not applicable.

REFERENCES

Adedeji, O. C., Mustapha, A. K. & Ajala, R. B. (2019). An assessment of Knowledge and awareness of noise induced hearing loss among saw millers in Osogbo. The proceeding of 11th Annual Conference on Environment and 2nd Specialized Workshop for Environmental Health Practitoners held at Institute of Ecology Basement Hall Obafemi Awolowo University, Ile-Ife, Nigeria on 3rd-5th September, 2019.

Adeoye, O. A., Adeomi, A. A., Adewole, A. O., Israel, O. K., Temitayo-Oboh, A. O & Olarewaju, S. O. 2014. Wood dust particles: Environmental pollutant in Nigerian sawmill industries. *Journal of Environmental and Occupational Science*. https://doi.org/10.5455/jeos.20140512123536

Adhikari S. &Ozarska, B. 2018. Minimizing environmental impacts of timber products through the production process "From Sawmill to Final Products". *Environmental System Research* 7:6. 1-15. https://doi.org/10.1186/s40068-018-0109-x

Akinyele, D. O, Amole, A. O, Oyadoyin, O. E, Olabode, O. E., Okakwu, I. K. &Abimbola, K. S. 2022. Analysis of Multi-Distributed Generation Systems Based on Solar/Biomass/Natural Gas/Diesel Energy Resources for Off-Grid Application. *Nigerian Journal of Technology* (NIJOTECH) Vol. 41, No. 4.

Atkinson R. (2024). Air Pollution: Environmental Health and Climatic Perspectives. J Ind Pollut Control. 2024;40: 003

Balboni, B. M., Chatukutaa, S. T., Mullerb, B. & Wessels, C. B. (2023). The sawmill yield increase potential with manufacturing increased wane and random width boards for engineered wood products. *Wood Material Science & Engineering*. https://doi.org/10.1080/17480272.2023.2229279.

Dudziec, P., Stachowicz, P. & Stolarski M. J. 2022. Diversity of properties of sawmill residues used as feedstock for energy generation. *Renewable Energy*. 1-44. https://doi.org/10.1016/j.renene.2022.12.002.

Edith P. M. & Edmund, N. 2012. Assessment of the impact of sawmill industry on ambient air quality at UTU community in Akwa-Ibom State Nigeria. *International Journal of Natural Sciences*, 3: 205-11.

Eziyi J., Akinwumi I. O., Olabanji I. O., Ashaolu O. O, Amusa Y. B. (2023). Noise Pollution: Knowledge, Attitudes and practice of sawmill workers in Osun State, Nigeria. Niger J Health Sci 2015;15:36-9 Fatusi A, Erhabor G. Occupational health status of sawmill workers in Nigeria. *Journal of the Royal Society of Medicine*, 116:232-6. 10.

FIM (2017) Update on global timber demand. FIM Service Limited, Burford.

Garcês, A., Afonso, S. M. S., Chilundo, A., and Jairoce, C. T. S (2014) Evaluation of different litter materials for broiler production in a hot and humid environment: 1. Litter characteristics and quality. *J. Appl. Poultry Resources* 22:168-176.

Gaussin M, Hu G, Abolghasem S, Basu S, Shankar M, Bidanda B (2013) Assessing the environmental footprint of manufactured products: a survey of current literature. *International Journal of Production Economics*,146:515–523.

Hemmat, W., Hesam, A. M. & Atifnigar, H. (2023). Exploring Noise Pollution, Causes, Effects, and Mitigation Strategies: A Review Paper. *European Journal of Theoretical and Applied Sciences*, 1(5),

995-1005. https://doi.org/10.59324/ejtas.2023.1(5).86

Hessel, P. A., Herbert, F. A., Melenka, L. S., Yoshida, K., Michaelchuk, D., Nakaza, M. (1995). Lung health in sawmill workers exposed to pine and spruce. *Chest*. 108:642-6.

Igben, J. L. (2019) Impact of Sawmill Industry on Maritime and Riparian Environments along Selected Rivers in Delta State, Nigeria. *Journal of Applied Sciences and Environmental Management*. 23 (3) 551-556.

Ige, O. M., Onadeko O. B. (2000) Respiratory symptoms and ventilatory function of the sawmillers in Ibadan, Nigeria. *African Journal of Medicine and Medical Sciences*, 29:101-4. 11.

Ijaware Victor Ayodele, Adefisoye Emmanuel Adetayo, (2024). Spatial Analysis of ambient air quality in the sawmill environment of Ondo Road, Ile-Ife, Osun state, Nigeria. Pollution and Effects on Community Health. 3(1); https://doi.org/10.58489/2836-3590/023

Ikiriko, T. D. & Gbarabe, F. O. (2024). Economic and social costs of flood disasters in Nigeria: Implications for sustainable national development. *Global Journal of Engineering and Technology Advances*, 2024, 19(01), 091–103. https://doi.org/10.30574/gjeta.2024.19.1.0043

International Institute for Environment and Development-IIED (2012). Renewable Energy Potential in Nigeria. *The SUNGAS project*. 1-33.

Lapsley Miller J. A, Marshall L, Heller LM, Hughes L. M. (2009) Low-level otoacoustic emissions may predict susceptibility to noise-induced hearing loss. *The Journal of the Acoustical Society of America*, 120(1):280-96. https://doi.org/10.1121/1.2204437

Leicester, R.H. (2001). Engineered Durability For Timber Construction. Progress in Structural *Engineering & Materials*. 3 (3):216–227.

Marshall L, Lapsley Miller J. A. Heller L. M., Wolgemuh, K. S., Hughes, L. M. Smith, S. D., Kopke, R. D. (2009) Detecting incipient inner-ear damage from impulse noise with otoacoustic emissions. *The Journal of the Acoustical Society of America*, 125:995-1013. https://doi.org/10.1121/1.3050304

National Emergency Management Agency- NEMA (2024). Flooding in Nigeria: Situation Report No. 1.1-15. https://reliefweb.int/report/nigeria/nigeria-floods-situation-report-no-1-25-september-2024

Nwabor Ozioma Forstinus, Nnamonu Emmanuel Ikechukwu, Martins Paul Emenike & Ani Ogonna Christiana (2016). Water and Waterborne Diseases: A Review. *International Journal of Tropical Disease & Health* 12(4): 1-14.

Ohagwu, C. J. Ugwuishiwu, B. O. (2011): Status of wood processing and storage in Nigeria. *Nigerian Journal of Technology* 30(2): 94-104.

Okorie Ngozi Nwamaka (2021): Mainstreaming Innovation in The Use of Secondary Raw Materials: A Case study of Sawmill Waste in Akure, Ondo State. *International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering* Vol. 9, Issue 1, January 2021 https://doi.org/10.17148/IJIREEICE.2021.9103.

Organization for Economic Co-operation & Development- OECD (2020): The economic cost of air pollution: evidence from Europe. *Economics Department Working Papers* No. 1584. Pp. 1-62.

Orru, K.; Tiittanen, P.; Ung-Lanki, S.; Orru, H.; Lanki, T. (2022). Perception of Risks from Wood Combustion and Traffic Induced Air Pollution: Evidence from Northern Europe. *Sustainability* 4, 9660. https://doi.org/10.3390/su14159660.

Rawat, Y.S.; Eba, M.; Nebiyu, M. (2023): Lumber Recovery Rate of Cupressus lusitanica in Arsi Forest Enterprise, Ethiopia. *Sustainability* 15, 1046. 1-14. https://doi.org/ 10.3390/su15021046.

Raimi, M. O., Adio, Z. O., Odipe, O. E., Timothy, K. S., Ajayi, B. S. & Ogunleye, T. J. (2020). Impact of Sawmill Industry on Ambient Air Quality: A Case Study of Ilorin Metropolis, Kwara State, Nigeria. *Energy and Earth Science* 3:1-25.

Rathipe, M. & Raphela, F. S. (2022). Assessment of Occupational Exposure to Noise among Sawmill Workers in the Timber Processing Factories. APPLIED ARTIFICIAL INTELLIGENCE 2022, 36, (1): e2110696 (3159 pages) https://doi.org/10.1080/08839514.2022.2110696

Shayo, Godfrey Michael, Elimbinzi, Elianaso, Shao, Godlisten N. & Fabian Christina (2023). Severity of waterborne diseases in developing countries and the effectiveness of ceramic filters for improving water quality. *Bulletin of the National Research Centre 47 (113)1-14.* https://doi.org/10.1186/s42269-023-01088-9.

Shamssain, M. H. (1992). Pulmonary function and symptoms in workers exposed to wood dust. Thorax47:84-7.

Teixeira A. S., Oliveira M. C., Menezes J. F., Gouvea B. M., Teixeira S. R., & Gomes, A. R. (2015). Poultry litter of wood shavings and/or sugarcane bagasse: Animal performance and bed quality. Rev Colomb Cienc Pecu 28:138-146.

The Guardian Nigeria (2022): How Lagos, Ogun generate huge wood wastes, pollute environment. October 20, 2022. https://guardian.ng.

United States Department of Labor's Occupational Safety & Health Administration. Wood Dust; 2008.

Villagrá A., Olivas, I., Althaus R. L., Gómez E. A., Lainez, M. Torres, A. G. (2014) Behavior of Broiler Chickens in Four Different Substrates: a Choice Test. *Brazilian Journal of Poultry Science*. Vol. 16. No 1. 67-76.

United Nations Development Programme-UNDP (2024). Nigeria Flood Impact, Recovery and Mitigation Assessment Report 2022-2023. https://reliefweb.int/report/nigeria/nigeria-floods-response-flash-update