A Review on the Environmental Impact of Saw Mill Waste Discharges in Nigeria

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Abstract

Saw mill is basic to the manufacture of wood products and is therefore considered very relevant as it is almost impossible to avoid the use of wood or its products in any given household. Although the development of this industry brings great gain, providing employment, sources of livelihood and products which gives comfort, it is yet associated with environmental pollution. The aim of this review is thus to establish the influence of waste generated from the saw mill on the environment and surface water quality in particular, using the Nigerian situation as a case study for other developing nations. Studies have shown that pollution from inappropriate storage and disposal of saw mill waste is not only physical but chemical as well. The manufacture of wood, especially those meant for external use or where they may be subjected to harsh artificial or natural conditions such as weather often requires its treatment with chemicals for preservation. These chemicals may be toxic or possess sufficient capacity to interfere with health or the aquatic biota when exposed. A review of previous studies on the impact of saw mill waste discharges on water quality has shown that surface water qualities especially is compromised when exposed to these waste.

Keywords: *Timber, Wood, Log, Sawmill, Surface water, Water quality.*

Introduction

Wood is a natural material often grown in the forest, where they can exist in their large numbers. It provides fruits as food, shade for both man and animals, used as a construction material and in furniture making. They are processed into various wood-based panel products including plywood, particle and fibre board, wooden items such as tools handles, sport goods, weaving equipment and wooden toys, furniture making, paper making and match making (Zhong *et al.*, 2013; Owoyemi *et al.*, 2016). Regular household wood products include tables, chairs, beds, doors, wardrobes etc. Wood is therefore unarguably important, and methods to achieve and maintain the sustainability of its products should be sought and applied (Jones *et al.*, 2002). Hence, the wood making industry, particularly the saw mill is considered in this study.

Advancement in technology and industry has certainly given man a rise in the standard of living and increased comfort. Similarly, the sawmill industry continues to provide employment alongside other benefits. Nevertheless, it carries with it an important issue which may mar its benefits if not appropriately addressed. For this reason, the present study reviews the existing knowledge on water pollution due to saw milling and wood waste generation in Nigeria. It aims to establish a relationship between the production of wood materials in the saw mill and deterioration of the environment with a focus on surface water qualities in particular. Its objectives are to determine the operational activities of the saw mill, waste generation and disposal, effect on surface water quality, the workforce and the immediate environment.

The Saw mill and Timber Processing

The saw mill and wood product manufacturing sector are generally classified into two subsectors namely; basic sawmilling and the final wood products manufacture and assemblage. Manufacturing plants purchase sawn timber and board materials to produce various designs of wood products such as furniture, or as may be required by the consumers. Sawmill uses round wood which is also called log to produce sawn and dried dimensioned lumber as output. Input logs are often stored in log-yards where they are irrigated or they may be stored in log-ponds. They are sorted by size and other relevant criteria in the log-yard, then transported via conveyor systems to the mill. It is common practice to debark the Logs as they enter the mill before they are wet sawn into a variety of lumber sizes. A typical process flow of the sawmill activity is as shown in Figure 1.

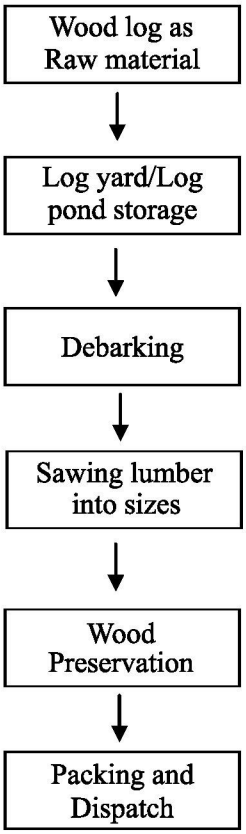

Figure 1: Typical sawmill and wood products manufacturing processes

Cutting and shaping of Timber in the mills are typically complex, involving multiple passes through the mill before any piece is ready for the next stage in processing. Sawn dimensioned lumbers are dried, either naturally or in kilns before proceeding to the market or they may be re-sawn and finished in a dry mill to provide a smooth input for other processes.

Chemical preservatives are often applied to Lumber intended for outdoor use as treatment. It is typically achieved in a pressurized vessel to ensure penetration of the chemical into the timber (Lebow, 2010; Porteous and Kermani, 2013). However, there are environmental concerns about the use of wood which have been treated with certain chemical preservatives (Hill, 2007; Kumar, 2007).

Sawmilling and resulting pollutants

Typically, manufacturing operations that produce wood waste such as from sawmills, paper mills and furniture making are sources of pollution in Nigerian water ways (Arimoro and Osakwe, 2006; Omole and Isiorho, 2011). These wastes often contain significant spectrum of organic substances capable of producing adverse effects on the environment and indirectly affect human health (FAO and WHO, 1991; Marchisio and Blasé, 1991). Proper disposal of sawmill waste has long been an intractable problem (El Haggar, 2010; Brunner and Rechberger, 2015). A significant amount of the sawn log remains in the yards as waste in various forms such as off-cuts, slabs, ends, and sawdust. Wastes are often mounted in heaps along the river bank when saw mills are located close by the river. Often the wastes spill over from the heaps into the water to contaminate it and hamper aquatic life. A summary of sawmilling, pollutants and their corresponding sources of generation are as shown in Table 1.

Table 1: Saw mill activity, pollutants and the corresponding points of generation

Activity	Pollutant source	Pollutant
Log storage and handling	Lumber	Bark and wood debris, total suspended solids (TSS) and leahates.
Untreated lumber/wood storage	Lumber and wood residue	Bark and wood debris, TSS and leahates.
Wood surface protection with chemicals and material storage	Chemical spillage during surface protection, mixing tank area, treated wood drippage and emission from spraying	Chemicals used for surface protection, Biochemial Oxygen Demand (BOD), Chemical Oxygen Demand (COD), TSS and other pollutants.
Wood treatment with chemicals for preservation	Drippage of chemicals after pressurized treatment, washing, spillage and leakages from equipment and tanks	Chemicals which may be toxic, BOD, TSS, oil and grease.
Fabrication of wood products and their assembly	Wood fabrication and assemblage of products	Exposure of lumber, residue and vehicle/equipment to precipitation.
Equipment/vehicle maintenance, repair and storage	Parts cleaning	Solvents, oils, heavy metals, acid/alkaline wastes.

Source: U.S. EPA (2006)

Impact of Saw Mill Waste on Water

Surface waters including rivers, lakes, and seas aside functioning as a source of freshwater for domestic and industrial uses serve multiple functions most of them being critical to human settlement and survival (Ayobahan *et al.*, 2014). They also provide water for irrigation. Although surface waters serve various purposes, they still receive large quantities of industrial, agricultural, and domestic waste, including municipal sewage. Surface water pollution may pose a serious threat to public health and aquatic ecosystem (Longe *et al.*, 2010).

Decomposition of wood residue is a slow process that can result when water percolates, or flows through wood residue or when wood waste is stored in pits or landfills where it may come in contact with groundwater in decades of leachate formation (Micales and Skog, 1997; Steenari, *et al.*, 1999). Typically, leachates from pure wood residue are dark coloured, petroleum like odour, and foams in water. Substances naturally occurring in wood include; resin acids, lignins, terpenes, fatty acids and tannins. Wood residue leachate produced creates another source of leachate (FAO, 1991).

Indicators of water quality

Water quality is usually described by the amount of substances or the concentration of certain chemicals present in the sample under investigation. The use of a water sample often helps to establish and describe its quality as "good" or "bad". Possible uses of water are grouped as; industrial, irrigation and domestic including drinking applications. The assessment of water quality generally involves comparing the measured concentrations of inherent substances (either chemical, physical or biological) with the natural or baseline concentrations and with established guidelines to protect human health or ecological communities (Longe *et al.*, 2010; Ladan, 2012). The quality of water is usually expressed by physical, chemical and biological parameters (Venkatesharaju *et al.*, 2010).

Surface Water Pollution with Wood Waste

In a study of the impact of effluent from the saw-mill on the physicochemical properties of Upper Ogun River (Abeokuta), Nigeria. Adeogun *et al.*, (2011) conducted a bi-monthly sampling using three sampling points; upstream and downstream of the point source of discharge over a period of six months (wet and dry season). Water samples were analyzed using standard procedures and the parameters determined were; Temperature, pH, Electrical Conductivity (EC), Total Solids (TS), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Phosphate (PO_4^{3-}), Nitrate (NO_3^-), Chloride (Cl^-), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The results obtained showed that the mean values of Temperature, BOD,

COD, TS, TDS, TSS, PO_4^{3-}, NO_3, Cl^- were significantly higher ($p<0.05$) during the dry season compared to the wet season. It was also observed that the values of DO were higher during the wet season compared to the dry season. Recovery studies as a measure of the self-purification capacity of Upper Ogun River to the saw-mill effluents showed that Chloride recorded the highest recovery value downstream from the point of discharge. All the studied parameters except temperature, pH and Chloride exceeded the water quality standards for fisheries and aquatic life specified by the National Environmental Standards and Regulations Enforcement Agency (NESREA) and the World Health Organization (WHO, 2004) maximum permissible standards for drinking water. It was therefore concluded that the water quality of Upper Ogun River was adversely affected and impaired by waste discharges from the saw-mill. Also, the alteration in water quality was more pronounced in the dry season compared to the wet season. Downstream, values of parameter were significantly higher than the corresponding levels upstream. The recovery capacity over the stretch of the studied river section was not good, an indication that Upper Ogun River is under continuous pollution.

Similarly, Okpiliya *et al.*, (2013) examined the variation in the physical, chemical and microbial properties of water due to timber processing in the Edibe-Edibe Creek in Calabar South Local Government Area of Cross-River, Nigeria. Results revealed that except for electrical conductivity, pH and iron, all other parameters were on the increase between the stations. However, nitrate had the same values in both stations. Generally, it was thus concluded that the water from the Creek being studied is 'not good' for domestic purposes because of the high concentration of nitrate and the acidity of the water.

The impact of sawmill wood wastes on the distribution of fish at the Sapele section of Benin River, Niger Delta, Nigeria was examined by Arimoro, *et al.*, (2007), over a five month period from March to August, 2005. A total of 558 individuals of fishes were collected by the fishing gear used, representing 23 taxa and 11 families. Three stations 1, 2 and 3 i.e., upstream of the site receiving wood wastes discharges, the impacted site and its downstream respectively, were selected for the study. Among the water quality variables determined, conductivity, dissolved oxygen, BOD_5, Nitrate-nitrogen, Phosphate-phosphorus and Transparency were significantly different ($P<0.05$) among the stations. The Orthogonal comparison using Duncan's multiple range test showed that station 2 (the impacted site) was the cause of the difference. The abundance of fish was significantly higher ($P<0.05$) in the unimpacted stations. Species richness and general diversity also followed a similar trend. These values were considerably higher in the unimpacted stations. The families Clupeidae, Schilbeidae, Characidae, Osteoglossidae, Mormyridae, Clariidae, and Bagridae which were all present in the unimpacted stations were not found in the saw mill wood wastes impacted site. Therefore the study concluded that sawmill wood waste does not only impact the water quality adversely but also affect the distribution and abundance of fish species in the locality studied.

Idise *et al.*, (2012) assessed the effects of solid wood waste discharges on the physico-chemical and microbial characteristics of Warri river. In this study, samples were obtained from three locations from September to November, 2010. Point 1 was 100 m before the discharge of the sawmill wastes into the river (i.e. Point 2) and point 3 was another 100 m after Point 2. Results showed that while the mean values for temperature, alkalinity, sulphate, carbonate, heterotrophic bacterial counts, coliform counts and fungal counts were lower between Points 1 and 2 but increased between points 2 and 3, the mean values for pH, turbidity, conductivity, total suspended solids (TSS), total dissolved solids (TDS), total solids (TS), biological oxygen demand (BOD), dissolved oxygen (DO), chemical oxygen demand (COD), nitrate and phosphate were higher between Points 1 to 2 and lower between Points 2 and 3. The mean values for pH, temperature and BOD were within the standard guideline while the values for COD, turbidity, conductivity and solids exceeded the standard limits. There were no statistically significant differences at 95% confidence level for the tested parameters between Points 1 and 3 except for pH, nitrate and fungal counts. The study concluded that the discharge of sawmill wastes into Warri river had negative effects on the water quality and the presence of luxuriant growths of water hyacinth emphasized this.

In a related study on environmental sustainability, Elijah and Isa (2015), investigated the impact of Okobaba sawmill industry on some biogeochemistry characteristics of the Lagos lagoon. The parameters; substantial metals and disintegrated supplements for both water and silt tests of Lagos tidal pond at Okobaba were studied for a period of six months, i.e. from March to August, as a part of the studies for the determination of the levels of tainting of the oceanic environment. Five stations were considered and an aggregate of thirty examples were gathered for both water and dregs tests each. Four out of the five stations extended along the water bank of Okobaba while the last (control) was taken after the third terrain span. Profundity of water ranged between 0.6 - 2.2 m, temperature ranged somewhere between 240°C and 300°C for air and 250°C and 350°C in water. 'Complete

strong' in water was seen to have a scope of 7010-21104. Saltiness of water body ranged from 5.7-22.8 mg/l. Scope of qualities for DO, BOD, alkalinity and pH qualities were given as 3.5-7.4 mg/l, 2106-12104 mg/l, 36.5-105.2 mg/l and 6.7-7.9 mg/l respectively. Results demonstrated that with the exception of Chloride, 'suspended strong', depth and transparency, all other physic-compound parameters and broken down supplements were not altogether diverse ($p>0.05$). Centralization of overwhelming metals, for example, Chromium, Nickel, Zinc and Iron demonstrated noteworthy distinction ($p<0.05$). It was thus presumed that the levels of sawmill waste contamination from Okobaba has brought about a contrarily significant effect on the water body. It was inferred from the results that the activity of Okobaba Sawmill industry has adversely affected the Lagos Lagoon.

In an investigation of the influence of sawmill wastes on the health of workers and the people within the immediate environment of the saw mill in Ondo State, Nigeria, Funmbi, (2015) examined a total of 240 respondents, consisting of 110 sawmill workers and 130 inhabitants of the residential areas around the sawmills who were drawn using accidental sampling technique. A validated self-structured questionnaire with reliability coefficient of 0.85 was used for the study. The data collected were analyzed using simple percentages and inferential statistics of t-test analysis. Findings of the study showed that the respondents did not have knowledge and experience on the importance of health education and the use of safety gadgets, protective devices and environmental health aids equipment were not sufficient. There was a significant difference in the awareness among the sawmill workers and the inhabitant of the residential areas about wastes generated in the saw mill, diseases contracted in the saw mills that can affect health, regular exposure to loud noise. It was therefore recommended that wastes should not be burnt. Saw mill operators should be provided with protective shield and gloves, and be monitored to wear them regularly. Provision of First aid box and toilets were also considered to be very important.

An examination of the volume of waste generated by sawmill industries vis-à-vis the management method adopted by sawmills and the prevailing diseases in the study areas were carried out by Akinbode and Olujimi, (2014). The primary data were collected through administration of structured questionnaire which was administered on household-heads within 1-kilometer radius of the selected sawmill industries. The second set of questionnaire was administered on operators of the saw mill, it examined the waste management practices and safety health measures adopted by the saw millers. The third set of questionnaire was administered on Town Planning Authorities, throughout the locality of the sawmill industries. Random systematic sampling method was employed to select the residents within the two study areas. Among others, results of the study under review revealed the volume of waste generated by each sawmill industry including the various modes of waste disposal practices adopted, the various means by which generated wastes can be put to use and specifically more relevant to the present study is the various environmental and health problems posed by the operation of the sawmill industries. It thus recommended that the quantity of wood waste generated can be reduced with improved conversion method, the use of conveyor belt to collect waste in order not to interfere with the sawmilling, plywood and veneer processes.

In Iretunde and Irepodun of Etsako-West Local Government Area of Edo state, Nigeria, two sawmills were examined by Anavberokhai (2008), with the aim to determine their operational activities and effects on the environment. The objectives were to determine the most significant environmental aspects of the saw mill and their organizational structure. In the evaluation of the environmental aspects, the detailed method of environmental impact evaluation proposed by Ammenberg (2004) was used. Here, each environmental aspect was weighed against nine identified criteria. Results obtained from the environmental aspect of the evaluation for both sawmills showed that the use of raw materials and emissions into the air are the most significant. In conclusion, the study observed that both sawmills were well structured but neither of them was registered under any environmental management system and were therefore encouraged to do so as it could help check their operational activities and reduce their environmental impact.

Conclusion

Reviews have shown that, although forest products are significant, the wood industries contribute to the pollution of the environment. The processing of round wood into various sizes and products necessarily generates wastes, starting with the felling of trees in the forest for logs, sawing of planks at the mills and re-sawing activities. These wastes include tree barks, cut slabs, strips, plain shavings and sawdust. Chemical preservatives or surface polish finishes are often applied to lumber intended for outdoor use as treatment, some of which are now restricted in developed nations. Leachate is produced from wood waste which is in contact with water. Surface water polluted with wood waste was therefore declared 'not good' for domestic purposes because of the

high concentration of nitrate and acidity of the water among other things. Reviews also showed that sawmill wood waste does not only impact the water quality adversely but also affect the distribution and abundance of fish species in the locality studied.

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