IMPACT OF SAW DUST ON AMBIENT AIR QUALITY AT DEI-DEI INTERNATIONAL TIMBER MARKET, ABUJA, NIGERIA

BY

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ABSTRACT

The activities of humans affects the environment through different ways creating negative impact to the natural environments and this need to be minimize greatly to make sure that there is a clean air, food and water for everybody on the earth. The aim of this research work was to assess the impact of sawdust on ambient air quality at Dei-Dei International Market Abuja, Nigeria. , Two different source of data collection were used which are primary and secondary source of data. The data collected from the field were subjected to statistical analysis To identify sawdust generationand disposal techniques in Dei-Dei market**.** Questions relating to sawdust generation, quantity and disposal techniques were asked and responses were subjected to descriptive statistics in order to determine the quantity of sawdust generated and the most commonly used disposal techniques in the study area. The result it indicated that 7% of the respondents said less than 10kg of saw waste is being generated daily in their stand; 17% of the respondents said 20-50kg were generated; 26% of the respondents said 60-80kg were generated while higher percentage of the respondents 48% said above 100kg of waste are being generated daily. The Pollutant Standards Index (PSI) was calculated for an overall assessment of air quality, There were both wide and narrow variations in the diurnal concentration levels of air pollutants monitored in the area. Nitrogen dioxide (NO2) ranged from 0.01 to 1.33ppm (0.16 ± 0.009), SO2 varied from 0.01 to 0.40ppm. Health Implication of Sawdustshows that, 3.3% sawmill workers and 4.2% inhabitants of the Environment signified that they had knowledge and experiences of the impact of sawmill operation on health. While a greater proportion of 42.5% sawmill workers and 50% inhabitants of the Environment said that they never had knowledge and experience of the impact of sawmill operation on health. It is concluded that Most operations carried out in the mills were largely supported by manual handling which often result to overexertion and a long term health hazards. Personal protection devices such as earmuff or plug, hand gloves were not used adequately and were often considered as irrelevant and disturbing. It is recommended that Measures such as the identification of hazards that are associated with wood dust and other substances in wood based industries should guide the workers in planning for processing activities in order to eliminate hazards.

TABLE OF CONTENTS

Contents **Page**

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

There is a great difference in the impact on the environment by organization and industries due to their activities of operation and use of raw materials. Organizations and industries are meant at transforming raw materials into finished goods in order to benefit their consumers which affect the environment indirectly or directly. The activities of humans affects the environment through different ways creating negative impact to the natural environments and this need to be minimize greatly to make sure that there is a clean air, food and water for everybody on the earth (Sammalisto, 2014).

Since the 1960s, there has been a growing interest on the level of damage to the environment by organizations and industries, which requires critical attention in order to minimize their impact on humans and its environment (Welford, 2000). The problem of global warming is becoming an growing concern globally today as most nations and organisations are now intended at ensuring that their activities create less negative environmental impact.

The generation of waste is a related aspect of livelihood; it cannot be stopped but can only be managed. The troubles that resulted to these wastes are numerous: they degrade the urban surroundings, decrease its aesthetic value, produce bad odours during the period rains and also pollute the atmosphere with smokes when the waste is burnt hysterically. It also brings health problems if they are not timely discarded; they turn to breeding areas for insects and worms (Dosunmu & Ajayi, 2012).

Disposal of solid wastes is the critical step in a management method. In advanced world, disposal is proceeds by most activities of engineering which includes quantity reduction and sorting (White *et al.*, 2011). This is done in order to sort out materials that can be changed into different economic value. Numerous methods of disposal waste exist. The options of any method depend on a number of factors. These factors according to Eerd (1997) include: features of the solid waste to be disposed, cost concern, presence of disposal site and cost of labour and technical implications of the method.

Saw dust is made of wood shavings from machining wood; it refers to the tiny sized and powdery wood waste produced
by sawing of wood (Maharani *et al.*, 2010). About 11-14% of the total volume of the log of wood is minimize to wood dust in milling operation; the dust usually depend mostly on the thickness of the timber sawed and mean width of the saw kern (Paulrud & Nillson, 2012). The size of particles in the wood dust packages are spread from very fine to coarse. The dust of wood is formed when different machines are used to shape or cut woods materials and the dust becomes a potential health problem when the particles of woods from these shaping and cutting processes are inhaled. Wood dust exposure may leads in internal and external health problems which may be immediate, long term or short term (Rongo *et al.*, 2015). Exposure to woods dusts have generally been reported in sawmills cabinet manufacturing industries and wood furniture. Exposures have also been seen in the finishing departments of plywood and particleboard mills, where wood is sawn and sanded. Exposure to wood dust also occurs among workers in joinery shops, window and door manufacturing industries, wooden boat manufacturers, paper and pulp manufacturers, logging and, construction carpentry (Rongo *et al*., 2015).

Various epidemiological studies have linked mortality and morbidity of individuals to exposure to particulate matters (Brauer *et al.,* 2015, Franklin & Zeka, 2017). While, working to enhance productivity, workers in sawmills industries inhale in wood dust (Judd, 2015), which is harmful to their physical condition. In Nigeria, studies have indicated the role of occupational exposure to pollutants within the environmental (such as wood dust) in the occurrence of respiratory diseases (Oppliger, 2015). High occurrences of respiratory symptoms, increased eye and nose irritations, skin symptom, and high occurrence of allergy as well as sensitivity symptoms have been experience among workers whom exposed to wood dust compared to unexposed (Shamssain, 2002). Generally respiratory health effect have been documented in workers exposed to a diversity of wood dust (Hessel, 2002), and reduced lung function is said to be associated with increased illness and mortality. Cancers have also been associated with wood dust exposure. The national institute for occupational safety and health considers both hardwood and softwood dust to be potentially carcinogenic to humans (United States Department of Labor's Occupational Safety & Health Administration; 2008).

Both hardwood and softwood dust have a Workplace Exposure Limit (WEL) of 5 mg/m3 8 hr time weighted average (TWA). They also both have a "sen" notification indicating they are capable of causing occupational asthma. In some cases skin contact with certain wood dusts can cause allergic or contact dermatitis. In addition, hardwood dust has a "carc" notification, implying it is capable of causing cancer. The International Agency for Research on Cancer (IARC) has classified wood dust as category 1 (carcinogenic to humans) carcinogen, and makes no distinction between hard and soft wood. Given the health effect that is associated with woods dust, employers have duties under the COSHH policies to avert exposure. Where that is not possible there are requirements to reduce exposure to all wood dusts as far below the WEL as it is reasonably feasible.

1.2 Statement of the Research Problem

As the wood demand and its products rise, the amount of wastes being gotten cannot but rise. Hence, one of the utmost environmental issue facing the city today is how to dispose waste appropriately, the waste being generated daily by the ever – growing activities of the sawmill industries. The sawdust frequently spilled on open spaces, sometimes occupies land for development. They also constitutes bad operational surroundings for those working in the area, due to waste accumulations over a time period most especially during the season of rains.

The amount of wood waste generated from sawmill industries operated by smallholders has now become a problem to the local environment. Even though parts of the wastes is used as domestic fire wood for household needs and bricks making industries, a large part of the wood wastes like log-ends, bark, and majorly sawdust remains unused in sawmill requires disposal. In order to clean up the factory spot, most sawmills just burn and also dump the wood wastes to the earth. Open Dumping and burning the wood waste ultimately causes the emission of Green House Gas (GHG) particularly methane (CH4) and carbon monoxide as a result of decomposition and combustion respectively (Tillman, 1978). For 100 kg wood wastes dumped, there would be approximately 8 kg of CH4 emission in the atmosphere (National Technical Experts, 2004). Fuwape (1998) concisely put it that sawmill industries accounts for 93.32% of the over all number of wood- based industries in Nigeria in 1997.

1.3 Aim and Objectives of the Study

This study is aimed at assessing the impact of sawdust on ambient air quality at Dei-Dei International Market Abuja, Nigeria. To achieve this aim therefore, the following specific objectives were set:

i. To identify sawdust and waste disposal generation in Dei-Dei market
ii. To examine the effect of the sawdust on ambient air quality
iii. To examine the effect of sawdust on soil and water within the Dei-Dei market
iv. Access the health implication of sawdust within the Dei-Dei market

1.4 Justification for the Study

There is a need for industries and various organizations to constantly review their environmental impacts in order to determine their level of conformity to existing tolerance level. The environmental reviews help the organization to get a clear view of the environmental state and also help to point out things that can be improved and which should be part of the company's plans of action. In implementing this review, a particular organisation is setup to lead the implementation systems which should include survey of the company's environmental aspect and the present environmental management systems (Brorson & Larsson, 2006).

The implementation of environmental management systems is becoming of great interest to industries and organizations. Organizations and industries adopt environmental management policies and carry out environmental audits and reviews in different cases as a result of public pressure, ethnical concern, commitments of local and central government, attraction of different customers (Welford, 2000). Environmental management system such as ISO14001, Eco-management and Audit Scheme, are examples of EMS used by organisations to amplify competence of operations which facilitates communications between organisations and its interested parties (Sammalisto, 2014).

The methods of carrying out environmental review may vary between organizations but is usually a comprehensive review of all aspects of the organisations environmental performance with performance indicators identified and targets and objectives suggested. Most environmental reviews use the SWOT analysis but this varies in depth between different organisations as the methodologies, analytical tools and concept used differs between organisations. Small organisations frequently have certain advantages over larger organisations in ensuring effective environmental management. In smaller organisations, lines of communications are generally shorter, organisational structures are less complex, people often perform multiple functions, processes are generally well understood, and access to management is simpler. These can be factual advantages for effective environmental management in small organisations (Welford, 2000).

Saw mills by nature generate a lot of wastes i.e. saw dusts, wood off cuts, wood backs, plain shavings, wood rejects, etc. National Technical Experts (2004) also explain that there are two sources of waste at wood working factory, namely wet-waste from wood log saw milling and dry-wastes from sawn-timber processing. A large area of saw timbers (which is going to be further processed into semi finished product) is being produced in the wood -working factories and partly supplied from smallholder sawmills. It is estimated that about 60% of saw-timber demand is produced in the factory and small holder saw mills supply the remaining 40%.

As the demand for wood and its product rises, the volume of wastes being generated cannot but increase. Hence, one of the most environmental problems facing the city today is how to dispose wastes properly, the wastes being generated daily by the ever – rising activities of the sawmill industries. The sawdust always spills on an open space, sometimes occupy lands for developments. They also constitutes bad working environment for those working in those areas, due to accumulations of wastes over a period of time particularly during raining period.

The amount of wood wastes generated from Dei-Dei International Timber Market has now become a problem to the local environment. Even though part of the wastes is used as domestic fire woods for household needs and brick making industries, a large part of the wood wastes like log-ends, bark, and majorly sawdust remains unused in sawmills requires disposal. In order to clean up the market area, most sawmills just burn and dump the wood wastes to the earth. Open dumping and burning the wood wastes ultimately causes the emissions of Green House Gas (GHG) especially methane (CH4) and carbon monoxide due to decomposition and combustion respectively. For 100 kg wood waste dumped, there would be approximately 8 kg of CH_4 emission to the atmosphere (National Technical Experts, 2004). Therefore, this study will be carried out to assess the environmental and health effect of saw machine and wood wastes in Dei-Dei International Market Abuja in order to proffer solution to the environmental effect of waste wood.

1.5 Scope of the Study

The study was carried out in Dei-Dei International Timber Market in Abuja, focused on environmental health hazards in the timber shed. It assesses the effects of timber re-sizing and plain operation on the air quality of the area, water quality test around the timber shed were examined the preparedness level of the timber shed workers to possible environmental hazards in the area; clinical test of the individual workers were not left out.

1.6 Study Area

Dei-Dei is a neighborhood in Abuja FCT. Abuja is the administrative capital of Nigeria, which is part of the Federal Capital Territory, and the most developed cities in Nigeria. (Encarta 2009) Abuja lies between latitude 7°20′and 9°15′ North of the Equator and longitudes 6°45′ and 7°39′East Greenwich Meridian, Abuja is geographically situated in the center of the country. Developments commence in 1981, the administrative capital was shifted from Lagos to Abuja in 1991.

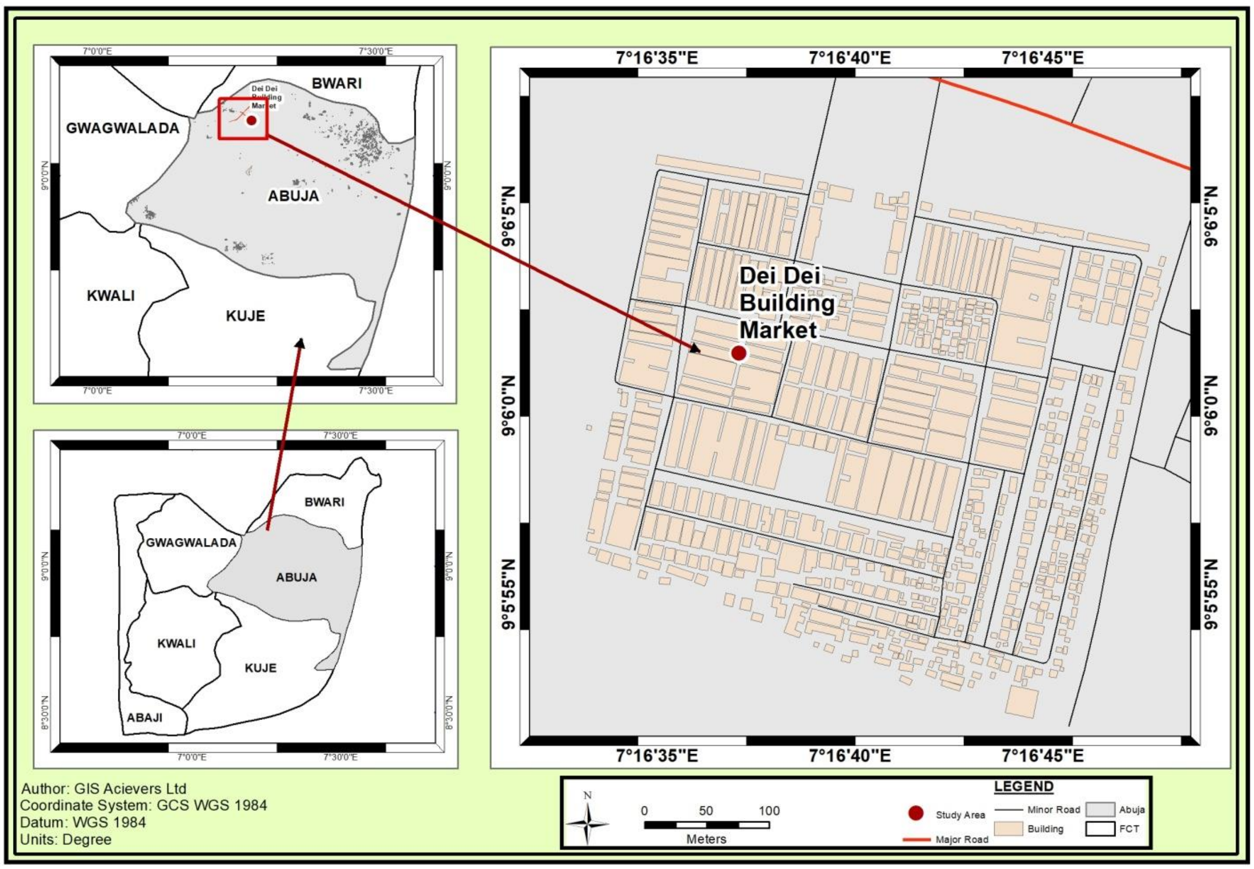

Figure 1.1: Federal Capital Territory showing the study area
Source: Geography Department Federal University of Technology Minna (2019)

The people of Dei-Dei are historically Gwari; however, at present, the town could easily be described as urban in nature by virtue of its agglomeration of people and activities, notable ethnic groups include the Gwari, Gwandara, Hausa, Yoruba, and Igbo. The notable occupations of the people of the town include: Civil service, Trading, Defense and security services and other businesses engagements. It is however the civil service that gave the town unprecedented growth mainly due to immigrant of people of both State and Federal institutions.

1.6.1 Vegetation and soil of the study area

The soil of the territory are generally shallow and sandy in nature, particularly on the major plains such as Ikugura, Roboes, and Rubochi , the high sand content particularly makes the soil to be highly erodible. Those on the famous Gwagwa plains are however deep and clayey, perhaps reflecting the influence of materials like gabbro and fine to medium texture biotic granite, pateches of rain forest, constituting about (7.4%) of the total mass vegetation (Nasidi, 2011).

Savannah wood land this covers about 12.85% of the total area and occurs mostly in the rugged and less accessible part of the territory, especially in the Gurara and Rubochi, half plains and surrounding hills. Shrub savannah occurs extensively in rough terrain close to hills and ridges in all part of the territory, cover about 12.9% of the total area space composition varies extensively (Nasidi, 2011).

The soil of the city shows a distinction intype and proportional mixture. The soils are clay silt and sand respectively. The geology produces soil characteristics of alluvial pediments, conbisols and levisols. (Abuja Master Plan, 2000). These soils influence the vegetation of the region and sustained peasant farming in areas like Zuba, Abaji, Shedda and Kuje. The vegetation of the FCT is normally classified as park savannah, with scattered trees, pockets of guinea savannah, woodland savannah, derived savannah and park land savannah. The valley of river Iku and Usuma around Gwagwalada and streams in Zuba shows characteristics of riparian vegetation.

1.6.2 Climate

The FCT has two seasons, rainy (April -October) and dry (November-march). The high altitude and undulating terrain of the territory act to provide a regular influence on its weather. During the dry season, the typical month being March, the temperature varies between 30^{o}C in the northeast to 37^{o}C in the southeast.

Abuja under Köppen climate classification features a tropical wet and dry climate. The area experiences three weather conditions annually. This includes a warm, humid rainy season and a blistering dry season. In between the two, there is a brief interlude of harmattan occasioned by the northeast trade wind, with the main feature of dust haze and dryness. The rainy season begins from April and ends in October, when daytime temperatures reach 28 °C (82.4 °F) to 30 °C (86.0 °F) and nighttime lows hover around 22 °C (71.6 °F) to 23 °C (73.4 °F). In the dry season, daytime temperatures can soar as high as 40 °C (104.0 °F) and nighttime temperatures can dip to 12 °C (53.6 °F). Even the chilliest nights can be followed by daytime temperatures well above 30 °C (86.0 °F). The high altitudes and undulating terrain of the FCT act as a moderating influence on the weather of the territory. Rainfall in the FCT reflects the territory's location on the windward side of the Jos Plateau and the zone of rising air masses with the city receiving frequent rainfall during the rainy season from March to November every year (Abuja Master Plan, 1990).

1.6.3 Relief

The lowest elevation in the federal capital territory is found in the extreme southwest where the flood plain of the river Gurara is at an elevation of about 70m above sea level. From there the land rises irregularly eastward, northward and northwest ward. The highest part of the territory is the northeast where there are many peaks over 760m above sea level, hills occur either as clusters or from long range. The most prominent of these include Gawa range in the northeast, the Gurfata range southwest of Suleja, the Bwari Aso range in the northeast the Idon Kasa range northewest of Kuje. Elsewhere in the territory there are many roundish isolated hills usually called inselbergs. In between the major hills are extensive plains, the most important of which are the Gwagwa plains, the Ikugurara plains. Indeed about 52% of the federal capital territory consist of plains, out of the plains the Gwagwa plains was selected for the building of the federal capital city (FCC) (Olugunja, 2000).

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Theoretical Framework

The theoretical framework is based on the theory of environmental reviews. This review has a central role in both ISO 14001 and Eco-Management and Audit Scheme (EMAS). It covers the review of legislation and other requirements, environmental aspects and impacts, the impact of environmental issues on sawdust, environmental management and analysis of some interested parties.

2.1.1 Environmental management systems

Most organizations aimed at increasing their efficiency, meeting the needs of their customers and as well improve their communication with stakeholders. In order to achieve this, organizations use modern standardization like ISO 14001 (ISO) and Eco-Management and Audit Scheme (EMAS). An Environment Management System (EMS) acts as a tool for managing the impacts of an organization's activities on the environment. It provides a structured approach to planning and implementing environment protection measures and monitors environmental performance. To develop an EMS, an organization has to assess its environmental impacts, set targets to reduce these impacts, and plan how to achieve the targets. There should be a total commitment from the top management staff to all other staffs in an organization in order for the EMS to be effective (ISO, 2017).

Some companies engage in environmental strategy in order to minimize the environmental impact of the company's processes, and making good use of available resources hence reducing environmental impacts and maximising profits (Brorson & Larsson, 2006).

2.1.2 ISO 14001

International organisation of standards (ISO) has developed over 17000 International Standards on a variety of subjects and 1100 new ISO standards are published every year (ISO). The standard for an environmental management system (ISO 14001:2004) ISO 14001,which was adopted in 1996 with the intent not only of raising expectations for environmental practice worldwide but also to facilitate trade and reduce trade barriers (ISO, 2008).

The ISO 14001 series encompasses EMS, auditing, performance evaluation, labelling, lifecycle assessment and product standards. The organizational evaluation of ISO 14001 is used to evaluate the firm or organization while the product and process evaluation includes labelling, life cycle assessments and environmental attributes in product standards and focuses on the evaluation and analysis of product and process characteristics (Tibor & Feldman,1996).

In the ISO 14001 series, organisation are expected to establish and maintain a procedure to identify the environmental aspects of its activities, products and services that it can control and over which it can be expected to have an influence in order to determine those which have or can have significant impacts on the environment. The ISO 14001 standards are process and not performance standards. The standards do not mandate a particular organization's optimum environmental performance level but describes a system to help an organization achieve its own environmental objectives (Tibor & Feldman, 1996).

2.1.3 Eco-Management Auditing Scheme (EMAS)

The Eco-Management and Audit Scheme (EMAS) is a voluntary initiative designed to improve companies' environmental performance only in the European nations and was initially established by the European Regulation 1836/93, which has been replaced by the Council Regulation 761/01.

EMAS ensures that organisations improve their environmental performance on a continual basis and through publications recognise and reward those organizations that comply with the environmental regulations and encourage more and more companies and organizations to continuously improve and contribute more into the development of the environment (EMAS, 2008).

EMAS requires that a company should identify the direct and indirect environmental aspects of its activities, products or services, arrive at a list of significant environmental aspects, based upon the relative environmental impact of each environmental aspect, identify the environmental aspects that can be controlled or over which you have influence and finally, develop a procedure to keep this information up-to-date (EMAS, 2008). The environmental aspects include the element of an organization's activities, products or services that can interact with the environment and as such create significant impact or problems on the natural environment.

EMAS been a standard used only in the European Nations, it is not a worldwide accepted standard like the ISO standards. The policies applications and implementation of EMAS is only restricted to European countries. EMAS is a European Union council regulation (No.1836/93), requiring implementation in all European Union Member States and as such it implies only to European nations. This thesis has only mentioned EMAS as an environmental management system but it has no relevance to the area of study and as such will not be further discussed or used. This is because the area of study for this thesis is located in Nigeria which is a country in Africa and as such is not guided with the EMAS regulations.

2.2 Utilisation of Forest Resources

Forest resource use involves the extraction of such resources (such as grazing for livestock), cultivation of crops and cutting of trees, FAO, (2011) hunting of wildlife and harvesting and collection of non-timber products. The problem of over exploitation of forest resources arose from the wrong concept that forest resources are naturally renewable and therefore the amount, or quantity as well as the methods of removal or harvest is inconsequential in renewability. (Pareen & Graaf, 2014) stated that Nigeria has a total forest area of 14,387,000 hectares in 1990. Five years thereafter, the Nigerian forest estate stands at 13,780,000 hectares with an annual change of 0.9% which according to (Oriola, 2011) is deplorable. Proper utilization of forest resources have not been put in place.

Most times, resources are over-exploited beyond the required need, either as food or as a healthcare. The left-overs cannot be returned to the forest or to the plant from which the part was taken. This leads to loss in resources due to uncontrolled harvest. The Proper utilization of these resources will ensure that resources are not over-exploited and wasted and are readily available and since forest resources could also serve as food and other needs, they play complimentary roles in agriculture in as much as they provide food in conjunction with agricultural production.

Proper utilization of forest resources could therefore ensure sustainability in agriculture. Reserve depletion due to over exploitation would not arise when resources are sustainably utilized and man's dependency would be two-fold (forest resources and agriculture produce), thereby sustaining agriculture.

A major concept of forest resources utilisation is the conservation of the resources, which is the method of using the resources wisely. Conservation of forest resources would lead to sustained agriculture in that resources would be properly managed, protected, harvested at levels that do not exceed re-growth and products efficiently utilized. Resources are not conserved but are rather exploited and wasted. Forest resources are harvested at alarming rates without cognizance of the resources' ability to replace themselves. The harvested products are wasted through inefficient utilization. For example the amount of wood waste in form of abandoned logs, rejected wood, off-cuts and slabs of wood at wood companies, logging sites and wood mills reveals that wood are not efficiently utilized after harvest (Gerwing & Vidal, 2011). Sustained agriculture among other things implies food availability or supply while the environment, in this case the soil, remains healthy.

2.2.1 The processing of wood technology and generation of waste

The FAO (2012) reported that Country has approximately 12.0 million hectare of forests, which is 13% of the land area totals, but mostly savannah woodlands with inadequate commercial potentials apart from the well destructive productions of the charcoal. Forests reserve total 8.6 millions of hectares, but 85% is situated in the savannah region and only 3.0 millions of hectare in the high forested region (FAO, 2013). Artisan sawing which was originally confine to the forests zone around great cities is now increasing into the isolated places of the forests; this sector produces income and employment of labourers and despite the danger posed, it is more completely beyond the control of the forestry administration. Adam *et al*. (2007) identify four main categories of different workers involve in the operations of milling: porters, tree fellers, , loading boys and tree scouts. In broad-spectrum, the bulk of the operations gang ranges from six through nine. With the exemption of the porters and tree feller, who could be the migrant, some workers were locally hired. Marfo *et al.* (2010) observe that it was not completely exact to recommend that saw -millers fails to provide timbers product; therefore, the issues always been the qualities of timbers, as most saw-mill supply are so called "discards."

According to Pulki (2010), wastes in these activities results from crudes methods, bucking techniques and felling. Illegitimate felling down actions are taken place mostly at night, changing of woods into lumber is fast in most cases done, the numbers of plank that will be extracts from the forests is more supreme to them as compel to the quantity recovers from different logs of trees (Adebagbo, 2012). Wastes generation starts from the forest. Crooked log, is off-cut, big branches of trees and sawdust are discarded in the forest. From factories, waste is generated in the form of saw-dust, slabs; as well as half-process material, the variety of stages of conversions of wood to our forest is connected with the generations of significant amounts of wastes as presently seen, as a predicament which start right from the forest (Onosode, 2008). For example, FAO (2010), indicated that fewer than two-third of harvested timbers are at last taken away from the forests for more processing. The processing using mechanical wood in sawmill as well as ply mill in Nigeria has also been establish to be connected with considerably amounts of woods generation of residue in form of trimming, off-cut, peelers, saw dust and slabs (Fabiyi & Oyegade, 2003).

Badejo (2010) observed that approximately 51-56% of the original woods brought to these industries that processed mechanically as marketable segment while as much as 46-51% end up as wastes. This condition is improper both from the sustainable utilization and efficiency of resources point of view.

2.2.2 Environmental degradations due to utilisations of forests wood resources

In this age of globalisation, environmental degradation is still alarming (Lemmers, 2002). It is of unreliable extent and it emanates from mismanagement of environmental due to combinations of nonchalant attitudes of populace to conservation the environment as well as general effect of recession of the economy. Over- logging has led to the occurrence of desertification of Sahel, sahelisation of the savanna and savanisation of the forests (Anon, 1994). At the present time, the whole Northern parts of the country are at risk of trailing its natural vegetations to desertification in the next 130 years if critical steps are not considered to curb desertification in the regions (Achellenu, 2003). *Gmelina arborea*, which become more popular plantations species in Nigeria was introduce from Sri Lanka in 1932. But after independence in 1960, importance was moved to forests exploitations for industrial developments and improved foreign earnings exchange. These desires accentuate the unregulated exploitations of the forests resources. In 1954 Nigeria was alienated into three administrative region, with each having its own forestry services. Each region enjoys defensive power over its forests resources and was responsible equally for supervising and monitoring the activities of the inhabitant authorities. The Country, nevertheless, retain the aspect of research in education and forestry. As other states were formed, the authorities over the forests resource were moved to the States Government (FAO, 2003).

Woods leachates and shavings are sources of inert solid and toxic pollutant that directly clog the gills of fishes (FAO, 1991), and ultimately reduced light penetrations which limit production. Pollution of aquatic environments, makes organisms of aquatic exposed (FAO, 1991), fish immune systems are weakened resulting to increase parasites incidence.

Manufacturing operation that produces raw woods, such as sawmills, paper mill and furniture's manufacturers are the main sources of pollutions in the Country waterways. Other ones include domestic wastes and agriculture which finds their means into the body of a river (Vega *et al*., 1996). The wastes always contains significant spectrum of organic substance proficient of producing undesirable effect on the biotic, chemical and physical environments and indirectly affects the health of humans (Adedoyin, 2013).

The section of Sapele of Benin Rivers in Delta State, the country is typical examples the streams receiving woods waste from sawmills industry. There is obvious evidence of scientific that if indecently managed, woods residues can unenthusiastically impacts the environments, contaminating and destroying fish habitats. Woods leachate residue is produce when the water flows and percolates, through woods residue; stores wood wastes in pits where it has contacts with ground waters that create another leachate source (Oriola, 2011).

Typically, pure wood residue leachate is a black liquid with petroleum like odour that cause foaming water. Woods residue decompositions is a sluggish process that can results in decade of leachate productions of substances naturally found in woods, such as resin acids, lignins, terpenes, tannins and fatty acids, dissolved from these concentrations. In fact, the leachate can smother spawning grounds areas, declining fish abundance and variety (Adedoyin, 2013).

2.3 Human Health Effect

2.2.2.1 Wood allergens

Exposures to any woods dust can cause problems of health and the problem is depends on the amounts of exposures and the body chemistry of the individuals. Most of these are sensitizers and the health challenges may not show -up till a certain amount of exposures. Most of these have dissimilar common names and the scientific descriptions are somewhat inexact mostly at the retail levels. Beside these, and most other woods, there can be serious health issues in epoxies, glue, similar and finishes used in woods working. Whatever thing that is used as liquids and dries to solids has solvents that evaporate. These solvents are capricious to extremely volatiles and can have very severe health problems.

2.3.1 Noise pollution

Noise pollution is the presence of noise in the environment that is offensive or harmful to the human ear and that interferes with the normal life. Sounds of high frequency are more annoying and potentially more damaging than low frequency sounds. The principal factor in noise that causes damage is the noise intensity which is measured in decibel (dB) (Bellamy, 2007).

Effect of noise on health is behavioural in nature; the discarded sounds can damages psychological and physiological health. Noise pollutions can cause aggression and annoyance, tinnitus, hypertension, hearing loss, high stress levels, sleep disturbance, and other harmful effect Moreover, hypertension and stress are the primary causes to health challenges, while tinnitus can leads to severe depressions, forgetfulness, and at times fright attacked (Field, 2003; Kryter, 2005).

Chronic exposures to noise can cause noise-induce hearing loss. Older males expose to important occupational noise demonstrates significantly reduce hearing sensitivity than their non-exposed peers, though differences in hearing sensitivity reduces with time and the two groups are undistinguished by age seventy-six (Rosen & Olin, 2005). A comparison of Maaban tribesmen, who were unimportantly expose to transportations or industrial noise, to a typical U.S. population showed that chronic exposures to fairly high level of environmental noise contributes to loss in hearing (Rosen & Olin, 2005).

High levels noise can contributes to cardiovascular effect and exposures to fairly high level during a sole eight period hour causing a statistical increase in the pressure of blood of five to ten point and an enhance in stress (Rosen & Olin, 2005), and vasoconstriction leading to the increased blood pressure noted above as well as to increase incidences of coronary artery diseases.

Noise pollutions are also causes of annoyance. The 2005 study by Spanish researchers found that in urban places household are willing to pay approximately three Euros per decibel per year for noise lessening (Jesús *et al*., 2005)

Noise has harmful effects on animal which causes stress, which increases risks of death by changing the delicates balances in predators and prey detections and the avoidance, and by intrusive with their use of different sounds during communications particularly in relation to reproductions and in navigation. Over exposures can leads to permanent or temporary loss of hearing; an impacts of noise pollution on animals lives is the decline of usable habitats that noisy places may lead to, which in the case of endanger species that may be part of the path to extinction. One of the best known cases of damages caused by noise pollutions is the death of different species of beach whales, brought on by the loud noise of military sonar (Balcomb, 2004).

Europeans Robin living in cities environment are more liable to sing at nights in areas with high levels of noise pollutions during the day, suggesting that they sings at night as a result it is very quieter, and their messages can spread through the environments extra visibly (Fuller *et al.*, 2007). Interestingly, the same study shows that morning noise was very strong predictors of nocturnal singing than during the night-period lights pollution, to which the incident is always attributed.

Zebra finch becomes less exact to the partner when exposes to noise at the traffic. This could touches a population evolutionary trajectory to selects traits, sapping resources usually devotes to other activities and thus leads to profound genetics and consequences of evolution (Milius, 2007). Loss of hearing as a result of noise pollutions is known as sociocosis. Table 2.2 indicates occupational health and safety administrations permissible exposures of noise for an eight- hour work days

2.3.2 Surface water recipient of large quantities of waste

Surface water (seas, rivers, and lakes) are of different source of waters for households, industrial, and agricultural uses. As such, they are also the recipients of huge quantity of agricultural, industrial, and domestic wastes, including sewage from municipals. Contaminations of surface waters, containing unknown and known compounds, may bring severe public health and aquatic ecosystems danger (White and Rasmussen, 1998, Ohe *et al*., 2004 and De'Morase *et al*., 2007). Heavy contaminations of the Songhua River are as a result of industrial wastes water and domestic sewage. In a previous study (Jin *et al*., 1998), 138 organic compounds were detected in the Songhua River by gas chromatography/mass spectrometry (GC/MS). Of these compounds, polycyclic aromatic hydrocarbons (PAHs) were the most prevalent, followed by nitrobenzene and phenylamine, phenols, phenolic acids, and esters. A total of 44 of 138 (31.9%) organic compounds were the priority pollutants of US Environmental Protection Agency (EPA). Zhang *et al*. (2002) reported that 185 organic compounds were detected by GC/MS in water samples taken from the Songhua River. In these compounds, 27.0% were aromatic compounds, 16.8% were diolefine compounds, 16.2% were PAHs, and 40% were other compounds. Of the total number of 185 organic compounds, 45 (24.3%) organic compounds possess genotoxicity and 18 organic compounds belong to the priority pollutants of the EPA. An epidemiological investigation indicated that the organic contamination in the Songhua River was a risk factor for tumour development among the residents who lived along the Songhua River (Zhu *et al.*, 1985). These contamination sources were either partially treated or untreated discharges from chemical industries, petrochemicals industries, oil refineries, oil spills, rolling steel mills, untreated domestic sludges and pesticides runoff. These studies demonstrated that these environmental mixtures contained many toxicants which may have carcinogenic potential.

Dissolved organic matter (DOM) in natural waters is one of the most dynamic reservoirs of organic carbon in the carbon cycle with the amount in the lakes and oceans estimated to be equal to the CO_2 content of the atmosphere (Hansell and Carlson 2001). Aquatic photochemistry of the absorbing portion of DOM (Chromophoric Dissolved Organic Matter, CDOM) has been studied for more than 25 years and the interest in this area continues to be strong (Nelson *et al.*, 1998). The interest in dissolved organic matter results from several aspects of its chemistry:

1. As a major absorber of sunlight in natural waters;
2. Is widely thought to be the source of reactive oxygen species in natural waters;
3. May also serve as a source of carbon and other nutrients in aquatic systems,
4. Is extremely important in water treatment.

2.3.3 Air quality

Due to the high population density and intensive industries, anthropogenic Nitrogen (N) emissions from cities have inevitably become prominent sources for elevated regional N pollution, which influences the air quality of cities and poses threats to surrounding ecosystems (Manisalidis *et al.*, 2020; WHO, 2019). Therefore, it is important to identify the sources and behaviour of urban-derived atmospheric N pollutants, which is of great value for reducing urban N release and protecting the environment around cities. However, atmospheric N deposition includes a wide range of gaseous compounds, aerosols and particulates, which has made it very difficult and expensive to undertake long-term instrumental monitoring and simultaneous measurements (Bobbink 2010; Zhu, 2016). Therefore, information of N deposition variation around cities is really rare. On the regional scale, the daytime sea breeze and the night time land breeze circulations caused by the differences in thermal properties of land and water surfaces limit the diffusion of an air mass by recirculation of contaminants (Tian, 2018).

On the local scale, the fumigation of elevated plumes into the thermal boundary layer can trap pollutants and lead to an increase of ground level concentrations. To better understand these processes, Ma and Lyons (2003) showed that if there is no strong synoptic forcing, the diurnal heating and cooling differences between the land and sea will determine the local wind circulations which affect the transport and diffusion of emission from surface sources. They proved that nocturnal emissions are swept out to sea by the land breeze only to be brought back over the land by the developed sea breeze leading to pollution episode. Liang and Jacobson (2000) study shows that the Mediterranean coastal areas are often characterised by significant photochemical air pollution episodes due to the intense solar radiation with local air pollution sources. Ozone is one of the most important pollutants in these Mediterranean areas as a consequence of the typical photochemical air pollution and dynamics of the Mediterranean regions (Ma & Lyons, 2003).

The World Health Organisation estimates that some 5 to 6 million people die prematurely every year from illnesses related to air pollution; Heart attacks, respiratory diseases, and lung cancer are significantly higher in people who breathe dirty air, compared to matching groups in cleaner environments (WHO, 2019). The most common route of exposure to air pollutants is by inhalation, but direct absorption through the skin or contamination of food and water also are important pathways. Because they are strong oxidizing agents, sulphates, SO_2, NO_x, and O_3act as irritants that damage delicate tissues in the eyes and respiratory passages. Fine particulates penetrate deep into the lungs and are irritants in their own right, as well as carrying metals and other polycyclic aromatic hydrocarbons (PAHs) on their surfaces (Esen *et al.*, 2008), Inflammatory responses set in motion by these irritants impair lung function and trigger cardiovascular problems as the heart tries to compensate for lack of oxygen by pumping faster and harder.

Carbon monoxide binds to haemoglobin and decreases the ability of red blood cells to carry oxygen. Asphyxiants such as this cause headaches, dizziness, heart stress, and can even be lethal if concentrations are high enough. Lead also binds to haemoglobin and reduces oxygen-carrying capacity at high levels. At low level lead causes long-term damage to critical neurons in the brain that result in mental and physical impairment and developmental retardation (Sanders *et al.*, 2009).

2.3.4 Wood utilisation impact on the soil

Soil is another great natural resource. It is a combination of mineral and organic matter structurally arranged in layers, and capable of supporting plants and animal life. Soils cannot exist without plants, and plants are dependent on soils for support, air, water, and nutrients. Soils are highly variable in nature. This variation includes their structure, layering, colour, range of particle sizes, chemistry, nutrients, acidity, temperature, water content, thickness, organic content, and its associated biota. These properties vary because of differences in the parent material, climate, topography, organic content, and the amount of time it has to develop.

Changes in one or more of these factors may drastically alter the soil properties, changing its nature and ability to support particular plants species. These changes can happen very easily, having profound effects on the soil and the landscape such as vegetation reduction, soil erosion, slope instability, increased flooding, and more sediment in rivers. The major changes induced by human activities include chemical changes (salinization and laterization), structural changes (compaction), hydrological changes, and soil erosion. In many ways human health is closely related to the quality of soil and especially to its degree of pollution (Steffan *et al.,* 2018). Soil can be considered a sink, but also a source of pollution with the capacity to transfer pollutants to the groundwater, into the food chain and into the human body. In particular, in urban and industrial areas soil influences both the quality of life and the health of people (Abrahams, 2002; Beniston *et al.,* 2015). Apart from the negative influences on human health, soil pollution can also cause serious economic losses. Soil contamination, be it locally concentrated or diffuse, is also recognised by the European Soil Strategy (European Commission, 2008) as one of the main threats to soil quality. Sources of pollution include traffic, industrial emissions, waste disposal, and the weathering of building structures.

Local communities are becoming more and more aware of and concerned by the consequences of soil pollution for their quality of life and welfare. Also governmental and regional institutions are devoting increased attention to soil pollution problems, recognising the essential ecological functions and ecosystem services of soils in terrestrial environments (European Commission, 2008). Initiatives have been started to limit and prevent further soil degradation and to examine applicable soil remediation methods. Metals are the most studied soil pollutants because of their ubiquity, toxicity, and persistence. They occur naturally in the environment. Some are essential for the metabolism of living organisms at low concentrations (Brevik, 2013). Above certain concentrations, all metals have adverse effects on human health. The health of young children, who have a higher rate of absorption, is particularly at risk (Vahter, 2008; Rahman, 2010). Being chemical elements, metals are not subject to metabolic breakdown (Liaw, 2008; Hall, 2009). Some metals, such as cadmium, accumulate in the human body over a long period of time so that negative effects may appear only after a long period of chronic exposure. Metals differ in their reactivity and this influences their availability in soil for uptake by organisms and transfer into the food chain (Zhang, 2004; Tian, 2009). In most countries, threshold values for soil metal pollution have been issued by legislation. Usually, these values are based on the amount of metals that are extracted from the soil by means of strong acid digestion. Such extractions represent the total extent of pollution. Only a fraction of the contamination, however, poses an acute risk of being taken up by biota or leaching into waters.

2.4 History of Sawmills

The first 'modern' sawmill was established in 1909 (Kerr, 1998). The sawmilling industry in Nigeria is dominated by small-scale, privately owned establishments. These mills, located largely within city centre around the country, have individual production capacities of about 500 cubic metres of lumber per annum and well over 1,500 across the country (Adeyoju, 2001; Akindele *et al.,* 2001). They are a major employer of semi-skilled/unskilled labour and a facilitator of socio-economic development. Today, Ebute-Metta, the location of the first pit sawing in the Country, also has the largest concentration of sawmills, numbering about 200. This accounts for 93.32% of the total number of wood based industries in Nigeria (Fuwape, 1998), fraught with the problem of low recovery rates. Recovery rates vary with local practices as well as species (FAO, 2010).

The local timber resources upon which Ebute-Metta and other sawmills depend for survival have not been managed in a sustainable manner. Thus, Nigeria has suffered much deforestation like the rest of Africa and the tropical world particularly in the 1980s (Barany *et al.,* 2003). As a result, the population of merchantable timbers in these forests has continued to decline. To be able to cope with the imminent difficulties in satisfying the ever-growing demand for lumber in the country, appropriate sawmilling practices which encourage high conversion efficiency and minimal waste generation, will be required. During conversion of logs, it has been estimated that the bark constitutes about 12% of the residue while slabs, edgings and trimmings amount to about 34 %, saw dust is estimated to be about 12% of the log input. Further processing might take place resulting in another 8% waste (of log input) in the form of saw dust, and trim end (2%) and plainer shavings (6%). The lumber recovery factor in most sawmills varies between 45 and 55% (Fuwape, 1998). Badejo (2010), gave an estimate of wood residue generated by Nigerian sawmills to be 1.72 million m^3 for the year 1981 which rose to 3.87 million m^3 by 1993 by Badejo (2010) estimate.

The natural forests, mainly rain-forests, which constitute just about 10 per cent of Nigeria's total land area, are the sources of about 80 per cent of the timber needs of the Country (Oriola, 2009; Larinde, 2010). The wood-based industries depend on the natural forests for the bulk of their wood raw materials. Larinde (2010) opine that although large areas of plantations exist, the natural forests are greater attraction to timber contractors due to their wide variety of species and sizes. Nevertheless, in recent times plantation forests have been churning out considerable volumes of timber to reduce the pressures on the natural forests to supply wood needs (Oriola, 2009). This is also evident by the extensive exploitation of thick plantations in the south western parts of the country for various wood products.

2.5 Previous Studies

Until recently many researchers have shown interest in the field of environmental management systems and the evaluation of significant environmental aspects. The review of different literatures on Environmental management systems forms an important part in a thesis where its purpose is to provide the background to and justification for the research undertaken and looking at what work has already been done in relation to the research area for this thesis. Some of their findings and suggestions are reviewed here.

Schebek *et al.* (2006) carried out an assessment for Volkswagen in Emden in Germany to determine its environmental impacts and environmental targets within environmental management system (EMS). The main aim of their research was to develop a systematic verifiable and reproducible approach to comply with the revised EMAS scheme.

The EMAS scheme according to Schebek *et al.* (2006) only assigns a central role within the environmental management systems and as such does not provide a method of assessing the environmental aspects with regards to their environment. The EMAS guideline only outlines the significant environmental targets. The EMAS comprehensive list gives the necessary environmental aspects to be considered which includes energy and material-related aspects such as energy requirements or emissions to air or water as well as aspects such as the risk of environmental accidents or visual appearance (Schebek *et al.*, 2006). Schebek *et al.* (2006) identified in there researches the quantitative assessment of impacts and the possible ways with which quantitative assessment of environmental impact can be carried out.

Based on the conclusion of their research, the Ecopoint method of environmental impact assessment was selected as the best method for the evaluation of the Volkswagen production site. This method of environmental impact assessment is based on a single score and uses standardized method of identification and assessing the environmental effects. This method also has pitfalls as the Ecopoint method is associated to Switzerland and as such it is not globally accepted. The second pitfall in the method is that it is based on political targets and legal thresholds, which are only partly based on scientific knowledge.

The review to determine the environmental aspects when manufacturing products mainly out of metals and or polymer in their production phase was carried out by Zackrisson (2005). The research was aimed at offering evidence that a production phase focus in environmental management is justified at least environmentally and to demonstrate a method for identifying and evaluating environmental aspects associated with metals and or polymer in their production phase

Zackrisson (2005) in his research identified the need of first determining the initial environmental review by which a deeper understanding is needed about an organization environmental impact before an environmental management system is developed. In his research, he carried out an environmental review of 11 companies in Sweden using the Industrial research and development corporation (IVF) template for initial environmental review to investigate the significance and ranking of environmental aspects from a particular manufacturing sub-sector that can be drawn from the available data. In his research, data were collected for the analysis using the ISO14031 standard. The ISO 14031 according to Zackrisson recommends that not only inputs and outputs should be considered for an environmental review instead management areas should also be included. Zackrisson included legal and other requirements, accidents, raw materials and compounds, chemicals and chemical products, energy consumption, waste and recycling, water and effluent emissions to air and water, transportation, local environmental impact as well as products in its data analysis.

As a result of the difficulties to compare different types of environmental impacts, Zackrisson (2005) converted all the identified impacts to the same units by weighting or evaluation method. This was to enable him determine which of the impacts is most significant in a lifecycle assessment. The use of the template for environmental review, which uses Swedish environmental priority strategies in product design value at each environment load unit, was used for the calculation. The method used by Zackrisson (2005) in his analysis uses the lifecycle assessment which involves the multiplication of an emission with the environmental load units (ELU) to compare and rank the environmental aspects quantitatively in order to identify significant environmental aspects.

By the use of this method, it was possible to achieve an approximate ranking of the companies' environmental impacts. As a means of certification of the results obtained, Zackrisson used the Eco-indicator 99 which is a method of calculation for weighting environmental impact by including the ecosystem, human health and scarcity of raw materials in addition with the EPS-2000 which uses the end-point approach and monetary weighting for assessment and the EPS-1996 were used to verify the results.

2.6 FEPA Standard and Regulation in Nigeria

Guidelines for emission limits from stationary sources represent maximum allowable levels of pollutants from a site, process, stack, vent, etc. with the objective of achieving a desired air quality. The prescribed emission limits depend on socio-economic and political considerations. Sources and types of pollutants are given in Table 2.1 based on available data in literature, the proposed guidelines for emission limits for particulates in stationary sources as well as for specific pollutants are given in Tables 3.2 and 3.3, respectively.

Table 2.1 Sources and Types of Air Pollutants

Type	Aerosol	Gases	Vapour
Combustion process	Dust fume	SO_2	Organics, acids
Automotive engines	Fume, smoke	NO_2, SO_2,	CO, acids
Chemical process	Dust, mist fume, spray	Process dependent CO_2, SO_2, NH_3, H_2S	Odour, acids, sol-vents organics
Fluoro and electro-metallurgical process	Dust, fume	SO_2, CO fluorides	Organics
Petroleum Operations	Dust, fume	SO_2, H_2S NH_3, CO	Hydrocar bons, mercap tans

Source: FEPA, 2010

Table 2.2: Emission Limits for Particulates from Stationary Sources

Substance	Limits (mg/m^3)
COMBUSTION OF FUELS	
Dark burning (pulp mills)	250
Blast furnace gas burning	50
Central Stations	200-500
Coal burning	100-500
Oil burning	50-250
Heavy oil burning	50-300
Solid oil burning	100-500
Incineration of refuse	150-1,000
Asphalt plants	70-5,000
Carbon black manufacture	40-60
Cement production	150-500

Coal processing	..	..	..	..		150
Coke Manufacture (metallurgical)		..	..	..	..	40-60
Electrode manufacture (metallurgical)	..	..	..	..		150
Furnaces		..	..	..	..	75-600
Kilns (cement)	..	..	..	..		75-600
Kilns (ceramics)		..	..	..	..	150-600
Kilns (lime)		..	..	..	..	300-600

Source: FEPA, 2010

2.6.1 Ambient air standards

Since emissions from industries and other sources have impact on ambient air it is of utmost importance to prescribe guidelines for safe levels of air pollutants tolerable to humans, aquatic organisms and vegetation. Table 3.4 indicates Guidelines for Nigerian Ambient Air limits for conventional pollutants while Table 3.5 gives levels for specific substances in the air.

Table 2.3: Tolerance Limits for Ambient Air Pollutants

Pollutants	Long-Term	Limits	Short-term	Limits
	mg/m^3	+(hours)	mg/m^3	+(min.)
Acetic acid	0.06	24	0.2	30
Acetone	0.35	24	0.35	30
Ammonia	0.20	24	0.2	30
Aniline	0.03	24	0.05	30
Benzene	0.8	24	1.5	30
Cadmium	0.003	24	0.01	30
Chromium	0.001	24	0.0015	30
Dichloromethane	1.0	24	3.0	30
Diethylamine	0.05	24	0.08	30

Diethylether	65.00	12	155.0	30
Dimethylamine	0.005	24	0.005	30
Dimethyl disulphide	0.2	24	0.7	30
Carbon monoxide	1.0	24	5.0	30
Carbon tetrachloride	2.0	24	4.0	30

Source: FEPA, 2010

Note: *Concentration not to be exceeded for more than once a year.

2.8 Case Studies of Sawmill Industry in Nigeria

The saw mill industry is characterized by small scale operatives which constitute more than 90% of the entrepreneurs in the sector (Ogunwusi 2012, RMRDC 2009, Ogunsanwo, 2010, GWV Consultants, 1993). A major characteristic of the subsector is increasing number of operatives and decreasing performance (Ogunwusi, 2012). The capacity utilization in the industry is on the average of 37% and the lumber recovery rate 40-60% respectively as a result of old equipment (RMRDC 2009; GWV Consultants, 1994).

According to Olorunnisola (2000), the annual rate of return is between 15.2% and 44.3% while more than 70% of the workforces are manual labours. The saw mills used outdated technologies while only less than 10% used advance technologies. Although, the sawmill industry has grown from the pit sawing to circular saw head rigs and French manufactured CD4, CD5, CD6 horizontal band saws, mighty mite, brenta vertical, kernali brand, antiglo machine, jevo machine, primultini vertical and forestor (Omoluabi, 1994), there are only few established sawmills that use the Numeric Controlled (NC) devices. Technological improvement in this industry will impact significantly on log to plank conversion efficiency (Ogunwusi, 2012).

Plate I: Kernali BrandMachine in Dei-Dei Timber Market (2017)

Plate II: Antiglo Machine in Dei-Dei Timber Market (2017)

Plate III: Jevo Machine in Dei-Dei Timber Market (2017)

Changes in the raw material characteristics such as decrease in log diameter in Nigerian forests also have a strong influence on conversion efficiency (Larinde, 2010). Another major factor limiting growth in the industry is scarcity of economic timber resources. The short fall in installed capacity and actual capacity utilization occurred as the sawmills are structured to utilized large diameter logs which are now limited in the natural forest as small size timber dominate the present composition of Nigeria’s forest resources (Larinde, 2010; RMRDC 2003).

In Nigeria, round wood processing has reached the limits of available forest resources such that the future increase in wood production and revenue could be derived from further processing of sawn wood rather than expansion in sawmill and exploitation of wood resources (Larinde, 2010). Consequently, Omoluabi (1994), Oyegade (1997) and Larinde (2010) recommended that efforts should be geared towards having most of the wood industries in Nigeria integrated to enable the wood waste or wood materials which are not suitable for one mill to be channeled to other mills that can process them. This is one of the major reasons for encouraging industrial cluster formation for collective efficiency and growth of the industry.

Finding the right strategy for the many challenges involved in collecting wood dust and wood chip particles can be a real puzzle for a wood shop or wood manufacturing business. The tests that the industry faces today entail developing an efficient process that reduces costs, while maintaining profitable returns from capital assets, and creating a healthy work environment for their employees from reductions in the amount of wood dust particles. The needs for innovative strategies have been dictated by modern changes in wood working equipment. Wood manufacturing companies have moved from using hand tools to an automated process with high powered wood working equipment. The investment in a quality wood dust and wood chip collection system is essential to meeting the modern demands (Iwanski, 1999).

While developing an effective wood dust collection strategy, an understanding of compliance regarding the Occupational Safety and Health Administration (OSHA) rules and regulations by the business becomes an important factor. In the OSHA Limits for Air Contaminants (2009), wood dust particles are categorized as cellulose under case number 9004-34-6. The total wood dust amount a worker can be exposed to is 15 mg/m 3 and a respirable dust fraction exposure of 5 mg/m 3, Mg/m 3 means milligrams per cubic meter. The exposure is measured by figuring the parts per million. Used with mathematical formulas, it is factored as the dose of particles that is represented (Keith, 1996).

Sampling is examined to determine the collection and containment of wood dust and wood chip particles while analysing the equipment needed to meet or exceed the OSHA standards. Revealing the exposure amounts of wood dust in a workplace can be a valuable tool to management, not only for meeting regulations, but for the planning of future expansion and finding the areas of the wood shop or wood manufacturing areas that need attention.

An overall understanding of the source and the size of the particulate matter can change the strategy of collection and containment. Different sizes of dust from the variety of woodworking equipment can determine the areas of sampling and eventually the methods of collection. According to Nagyszalanczy (1996), the different categories of dust would include: large shavings that gather rapidly and provide the most challenges in terms of volume; chip sand sawdust that cover a wide variety of sizes and can also produce volume; and the last category is fine wood powder, which is the hardest to collect and the provides the most challenges in a collection strategy. The fine wood dust particles cause the most problems for detection and collection.

Filtration methods offer the best methods for controlling the fine dust. The best filters materials proved quite effective for fine particles. The best mass removal efficiencies for fine particles around 0.3 mg/m3 were over 80% for some loaded materials (Welling *et al.*, 2009). Similar toa regular filter on a home furnace, filtering is one of the dust control methods and helps pull the fine wood dust particles out of the air effectively. Iwanski (1999) found, the increased popularity of fine filter products has also allowed companies to significantly decrease the amount of fine dust in the air, potentially the most dangerous because of its invisibility.

2.9 Health Concerns of Saw Dust

The health hazards created by the wood dust and wood chip particles are the areas of concern that center on the long-term effects on health and safety of the employees. Workers exposed to wood dusts have experienced a variety of adverse health effects such as eye and skin irritation, allergy, reduced lung function, asthma, and nasal cancer.

Therefore, the National Institute for Occupational Safety and Health (NIOSH) recommends limiting wood dust exposures to prevent these health problems. What are the causes and categories of the health hazards related to wood dust? When it comes to determining the hazards of wood dust, particle size matters. Fine wood dust that is produced by sanding poses the most danger to the employees in the workplace. Respirable dust is a component of particulates in the air stream that will deposit within the gaseous exchange areas of the lung. Respirable particles are just the right size to travel with inspired air into the alveoli of the lung, (Boss, 2001). The long term affects of wood dust canvary in condition and degree of symptoms. Headaches, nasal irritations, shortness of breath, acute and chronic cough, chest pain, and skin disorders can occur with exposure to wood dust particles. An extensive study completed by Milanowski *et al*. (2002) found, Strong evidence that exposure may lead to the development of work-related symptoms and lung function impairment.

How is the exposure to wood dust particles measured? The level of exposure is determined through sampling the air in the workplace. Air samples, like most environmental samples, are taken for one of two basic reasons: to gather internal data, or to attempt to prove compliance with a regulation (Bodger, 2003). Documented compliance and improvements can become a company asset in the process of satisfying regulators. Sampling becomes a challenge in determining exposure limits and calculating the doses to employees. Sampling is a process of determining the amount of exposure a person receives overtime. Some of the possible exposure assessment measurement parameters are as follows: particulate concentration in the breathing zone (concentration x time = dose) (Keith, 1996).

Limits can be directed by other organizations and statutes depending on the severity and the amount of exposure. The following Table 1 shows the occupational exposure limits set by different organizations and the Occupational Exposure Limits (OEL).

Table 2.5 Occupational Exposure level

Organization	OEL	8 Hour TWA	Basis
OSHA	Permissible Exposure Limit particulate not otherwise regulated (PNOR)	15 mg/m^3 total 5 mg/m^3 Respirable	Throat, skin, eye irritation, upper respiratory problems
NIOSH	Recommended Exposure Limit	1 mg/m^3 total	Pulmonary Function, Carcinogen
TLV ACGIH 2007	Western Red Cedar	0.5 mg/m^3	Asthma
ACIGH 2007	All other species	1 mg/m^3	Pulmonary Function

Note: "Several organizations have set standards or given recommendations for wood dust

Source: (Keith, 1996).

A study performed by Meo (2004), found that, The duration of exposure, particularly over eight years, to wood dust particles reduced a worker‘s Peak Expiratory Flow Rate (PEFR),or their ability to breathe out and show lung potency. Exposure becomes the determining factor to setting limits and the level of health issues in workers. Studies that examine exposure show a connection to long-term exposure of wood dust particles and serious health problems. To protect the worker from overexposure, OSHA has determined the exposure limits in the workplace by a weighted limit of an 8 hour work shift (Keith, 1996).

During a study that examined different types of wood dust emissions, Welling *et al.* (2009) determined that using sand paper on a piece of pine produced particle sizes of between.05 and .10 mg. The pine created larger particle sizes and fewer emissions than the MDF (Medium-Density Fiberboard) and birch plywood that was tested (p.93). The species and types of wood can determine the exposure limits and health condition risks.

Table 2.6: Respiratory Condition

Number of cases (000)		
	Incidence rate	
Goods producing(2)	2.7	1.3
Natural resources and mining (2)(3)	.2	1.6
Construction	.7	1.2
Manufacturing	1.7	1.4

Adapted from: "Illnesses by category of illness rates and counts." Bureau of Labor Statistics,

In contrast to other industry sectors, manufacturing workers have greater incidents of respiratory problems. Table 2 explains an OSHA survey of Non-Fatal Occupational Illnesses; as a comparison of different industry sectors for 2009, the information was withdrawn from a broader study with the focus here showing the number of cases involving respiratory conditions. In manufacturing, the numbers of cases are much greater than any of the other sectors; however, the incident rates are very comparable. The severity of health related illnesses have been linked to the exposure to wood dust, the size of the particles, and the types of wood products. The longer the duration of contact a person becomes exposed to fine particles of wood dust, the greater chance for serious health concerns.

2.10 Nigeria Regulation on Environmental Workplace Law

The Federal Ministry of Environment (FME) administers and enforces environmental laws in Nigeria. It took over this function in 1999 from the Federal Environmental Protection Agency (FEPA), which was created under the FEPA Act. FEPA was absorbed and its functions taken over by the FME in 1999.The Federal Ministry of Environment has published several guidelines for the administration of the FEPA and EIA Acts and procedures for evaluating environmental impact assessment reports (EIA Reports).Other regulatory agencies with oversight over specific industries have also issued guidelines to regulate the impact of such industries on the environment such as the Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) 2002, published by the Department of Petroleum Resources (DPR).

However, pursuant to the FEPA Act, each State and local government in the country may set up its own environmental protection body for the protection and improvement of the environment within the State. Each State is also empowered to make laws to protect the environment within its jurisdiction. All the States have environmental agencies and State laws; e.g. Abuja, the Federal Capital Territory has issued the Abuja Environmental Protection Board (Solid Waste Control/Environmental Monitoring) Regulations 2005 ("the Abuja Environmental Protection Board Regulations") which principally governs solid waste control in Abuja. In Lagos State, the Lagos State Environmental Protection Agency Law, was enacted to establish the Lagos State Environmental Protection Agency (LASEPA). LASEPA’s functions include monitoring and controlling the disposal of waste in Lagos State and advising the State Government on all environmental management policies. Lagos State has also enacted the Environmental Pollution Control Law, to provide for the control of pollution and protection of the environment from abuse due to poor waste management. Akwa Ibom State, has enacted the Environmental Protection and Waste Management Agency Law, which established the Environmental Protection and Waste Management Agency. This Agency is charged with responsibilities which include identifying and proffering solutions to environmental protection problems in Akwa Ibom, and monitoring and enforcing environmental protection standards and regulations.

The EIA Act was promulgated principally to enable the prior consideration of environmental impact assessment of public or private projects. Any person planning a project/activity which may have an impact on the environment is statutorily required to prepare an EIA Report, and the Report must set out the potential impact of the activity on the environment and plans for preventing/mitigating the same, as well as clean up plans. All such Reports must be approved by the FME. Attached to the EIA Act is a schedule of activities and industries for which environmental impact assessments are mandatory. These include Agriculture, Airport, Drainage and Irrigation, Land Reclamation, Fisheries, Forestry, Housing, Industry, Infrastructure, Ports, Mining, Petroleum, Power Generation and Transmission, Quarries, Railways, Transportation, Resort and Recreational Development, Waste Treatment and Disposal, and Water Supply.

Any person who fails to comply with the provisions of the EIA Act commits an offence and is liable on conviction, in the case of an individual, to a fine or to a term of imprisonment for up to five years; and fines are also imposed on guilty firms or corporations. Furthermore, the FEPA Act empowers the FME to require the production for examination of any licence or permit granted to any person, to enter and search any land or building, and to arrest any person whom they have reason to believe has violated any environmental regulation.

Environmental regulators have wide ranging powers in the event of violation of environmental permits and environmental laws in general. The FEPA Act gives authorised officers of the FME powers to:

i. require to be produced, then examine and take copies of any licence or permit, certificate or document required under the Act or regulations made thereunder;

ii. enter and search any land, building, vehicle, tent, vessel, floating craft or any inland water;

iii. cause to be arrested any person whom they have reason to believe has committed an offence against the Act or any regulations made thereunder; and

iv. seize any item or substance which they have reason to believe has been used in the commission of such offence or in respect of which the offence has been committed.

The LASEPA Law also contains similar provisions authorising officers to search and seize offending items and to arrest offenders. Some examples of offences under the LASEPA Law include the discharge of raw untreated human waste into any public drain, gorge, or any land in the State, and the discharge of any form of oil, grease, spent oil including trade waste brought about in the course of manufacturing into any public drain, water-course, water gorge and road verge. Similar provisions are contained in the Akwa Ibom State Environmental Protection And Waste Management Agency (EPWMA) Act. The EPWMA Act empowers inspectors to inspect premises and take samples of waste generated on premises. The EPWMA Act also provides that any person who commits an offence under the Act shall be arraigned before the Environmental Sanitation Court. The Environmental Sanitation Court was established pursuant to the EPWMA Act to try offending individuals or organisations. Offences under the EPWMA Act include burying or dumping expired drugs or chemicals without a permit, using gamalin 20 or any herbicide, insecticide or other chemicals to kill fishes or any other aquatic life in rivers, lakes and streams.

Nigerian environmental regulators have statutory powers to require the production of documents, take samples, conduct site inspection etc. in the course of carrying out their functions of preventing or investigating environmental damage. The FEPA Act empowers the FME to require the production for examination of any licence or permit granted to any person, to enter and search any land or building to take samples, conduct site inspections, interview employees and to arrest any offender. Under the Akwa Ibom EPWMA Act, Environmental Protection and Waste Management Inspectors are empowered to inspect environmental standards on premises during reasonable hours between 6:00 am and 6:00 pm. Similar provisions are contained in the LASEPA law.

2.10.1 Enforcement of environmental law on sawmill dust

The EIA Act was promulgated principally to enable the prior consideration of environmental impact assessment of public or private projects. Any person planning a project/activity which may have an impact on the environment is statutorily required to prepare an EIA Report, and the Report must set out the potential impact of the activity on the environment and plans for preventing/mitigating the same, as well as clean up plans. All such Reports must be approved by the FME. Attached to the EIA Act is a schedule of activities and industries for which environmental impact assessments are mandatory. These include Agriculture, Airport, Drainage and Irrigation, Land Reclamation, Fisheries, Forestry, Housing, Industry, Infrastructure, Ports, Mining, Petroleum, Power Generation and Transmission, Quarries, Railways, Transportation, Resort and Recreational Development, Waste Treatment and Disposal, and Water Supply. Any person who fails to comply with the provisions of the EIA Act commits an offence and is liable on conviction, in the case of an individual, to a fine or to a term of imprisonment for up to five years; and fines are also imposed on guilty firms or corporations. Furthermore, the FEPA Act empowers the FME to require the production for examination of any licence or permit granted to any person, to enter and search any land or building, and to arrest any person whom they have reason to believe has violated any environmental regulation.

The approach of regulatory agencies is the prevention of environmental damages, the regulation of potentially harmful activities and the punishment of willful harmful damage whenever this occurs. The environmental agencies also adopt the approach of engaging individuals and communities at risk of potential environmental damage in dialogue. The EIA approval process adopted by the FME involves a system of public hearings during the EIA evaluation process and interested members of the public are invited to such hearings.

2.10.2 Environmental permits

The different pieces of legislation on the protection of the environment contain provisions for the issuance of environmental permits. Such permits are required for all potentially environmentally sensitive activities and are typically granted by the FME and the relevant State agencies. Specific legislation on permits include the Radioactive Waste Management Regulations 2006 which provides that any person generating or managing radioactive waste must apply for and obtain a permit from the Nigerian Nuclear Regulatory Authority; the FEPA Act and the regulations made there under.

The National Environment Protection (Pollution Abatement in Industries and Facilities Generating Wastes) Regulations made pursuant to the FEPA Act provide that a permit will be required:

i. for storage, treatment and transportation of harmful toxic waste within Nigeria;

ii. where effluents with constituents beyond permissible limits will be discharged into public drains, rivers, lakes, sea, or as an underground injection;

iii. when oil in any form shall be discharged into public drains, rivers, lakes, sea, or as an underground injection; and

iv. for an industry or a facility with a new point source of pollution or a new process line with a new point source. Such an industry or facility shall apply to the agency for a discharge permit.

Some permits are industry specific; e.g. in the oil and gas industry, the Directorate of Petroleum Resources (DPR) also regulates environment issues, and operators in the industry are required to obtain the necessary permits.

The Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) 2002, published by the DPR provides that the Director of Petroleum Resources shall issue permits for all aspects of oil-related effluent discharges from point sources (gaseous, liquid and solid), and oil-related project development.

The EGASPIN also provides that environmental permits shall be issued for existing and new sources of effluent emission. All projects in the oil and gas industry must be issued with the requisite environmental permits, and failure to procure the same may lead to penalties.

Relevant state permits are also required i.e. pursuant to the Abuja Environmental Protection Board Act (Solid Waste Control /environmental Monitoring Regulations 2005), all sponsors of major development projects in Abuja must submit to the Abuja Environmental Protection Board ("the Board") details of the project i.e. its nature and scope, the site and area of the project, the activities to be carried out and any other relevant information. Upon submission, the sponsor is issued an Impact Clearance Permit by the Board. In Lagos State, the LASEPA law requires any person manufacturing or storing chemicals, lubricants, petroleum products, cement and other material used in building, radioactive materials, or gases in residential or commercial areas to obtain a permit.

2.10.3 Violation of permits

Environmental regulators have wide ranging powers in the event of violation of environmental permits and environmental laws in general. The FEPA Act gives authorised officers of the FME powers to:

i. require to be produced, then examine and take copies of any licence or permit, certificate or document required under the Act or regulations made thereunder;
ii. enter and search any land, building, vehicle, tent, vessel, floating craft or any inland water;
iii. cause to be arrested any person whom they have reason to believe has committed an offence against the Act or any regulations made thereunder; and

iv. seize any item or substance which they have reason to believe has been used in the commission of such offence or in respect of which the offence has been committed.

The LASEPA Law also contains similar provisions authorising officers to search and seize offending items and to arrest offenders. Some examples of offences under the LASEPA Law include the discharge of raw untreated human waste into any public drain, gorge, or any land in the State, and the discharge of any form of oil, grease, spent oil including trade waste brought about in the course of manufacturing into any public drain, water-course, water gorge and road verge.

Similar provisions are contained in the Akwa Ibom State EPWMA Act. The EPWMA Act empowers inspectors to inspect premises and take samples of waste generated on premises. The EPWMA Act also provides that any person who commits an offence under the Act shall be arraigned before the Environmental Sanitation Court. The Environmental Sanitation Court was established pursuant to the EPWMA Act to try offending individuals or organisations. Offences under the EPWMA Act include burying or dumping expired drugs or chemicals without a permit, using gamalin 20 or any herbicide, insecticide or other chemicals to kill fishes or any other aquatic life in rivers, lakes and streams.

Section 11 of the Harmful Wastes Act empowers the Minister charged with responsibility for works and housing to seal up an area or site used or being used for the purpose of depositing or dumping harmful waste.

Pursuant to section 37 of the Petroleum (Drilling and Production) Regulations 1969 (Drilling Regulations) the holder of an Oil Mining Lease (OML) or an Oil Prospecting License (OPL) is required to prevent the escape of petroleum into any water, well, spring, stream river, lake reservoir, estuary or harbour. The Drilling Regulations further authorises inspectors to examine the premises of the holder of the OML or OPL to ensure that such persons comply with the Drilling Regulations. Any person who fails to comply with the provisions of the Drilling Regulations may be prosecuted in court.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Data Collection

Data and information involved in timber shed operation, methods of disposing of waste, perception of the residents that are living close to the timber shed sites, air quality assessment and water quality test were carried out. The inhabitants and workers need to provide most of the information through their responses to the questionnaires and author's field work.

3.2 Source and Types of Data Collection

In this research work, two different source of data collection were used which are primary and secondary source of data collection. Relevant primary data was collected through structured questionnaires which were distributed to workers at the timber shed and individuals in the vicinity of the shed. Soil, water and air data were also collected directly from the timber shed. Secondary data involved data collection from the academic journals, texts book, gazettes and other related projects that have direct bearing on the research that were consulted and used. It also includes heath records from health care facilities around the study area.

3.3 Instruments for Data Collection

Different instruments for data collection were adopted for the success of this study. The following instruments need to be used to collect the data in achieving the objectives of the study are:

i. Reconnaissance Survey: reconnaissance survey of the study areas was embarked on in order to identify the site, also to note down some of the fact that questionnaire were not able to assess like number of inhabitant living close to the site, personal hygiene of the workers and their method of disposing their liquid and solid waste.

ii. Field Survey: Personal observation was carried out, types and manner of wood waste generation and management were observed, and digital camera was used to take the photographs of the operations, equipment and process of operation in the study areas. Photographs were taken where necessary to document physical conditions at the timber shed and activities during operation.

iii. Air Quality Assessment: The air in the timber shed was measured in the morning, afternoon and evening, the following air perimeter was observed and analysed; Carbon monoxide (CO), Sulphur dioxide (SO2), Ammonia (NH2), Nitrogen dioxide (NO2), Chlorine (Cl2). The concentration of the parameters at different time of the day was determined within the Timber Shed.

iv. water Quality Test: The parameters were tested in Federal Regional Water Quality Control Agency, Minna, Niger State following the practical guide to the design and implementation of fresh water quality studies and monitoring programmes edited by Jamie Bartram and Richard Balance, published on behalf of United Nations Environment Programme and World Health Organization (UNEP/WHO) 2006. The flowing parameters were tested:

i. Temperature
ii. Dissolved Oxygen
iii. Turbidity
iv. Conductivity
v. Total Dissolved Solid
vi. pH
vii. Fluoride (F)
viii. Manganese (Mn^{+})
ix. Ammonia (NH_3)
x. Nitrate (NO_3^{-2})
xi. Sulphate (SO_4^{-2})
xii. Nitrite (NO_2^{-})
xiii. Sodium (Na^{+})
xiv. Potassium (K^{+})
xv. Alkalinity
xvi. Calcium
xvii. Chloride (Cl^{-})
xviii. Magnesium (Mg^{2+})

v. Questionnaire/Oral interview: The questionnaire was designed based on findings from a comprehensive literature review which provided secondary data for the research. Question were asked in a simple way that both the timber shed workers and resident were able to provide answer to. Question relating to waste wood management, sources of water to immediate surrounding communities were asked.

3.5 Data Analysis and Presentation

The data collected from the field were subjected to statistical analysis. This was carried out after questionnaires have been coded. Questionnaires were subjected to the Statistical Package for Social Scientist (SPSS) 21 version. The analysis was subjected to descriptive statistics which involved the use of tables, percentages, charts and photographs.

3.5.1 To identify sawdust generation and disposal techniques in Dei-Dei market

Field survey was carried out in the study area, personal observation was made and structural questionnaire were used. Questions relating to sawdust generation, quantity and disposal techniques were asked and responses were subjected to descriptive statistics in order to determine the quantity of sawdust generated and the most commonly used disposal techniques in the study area.

3.5.2 To examine the effect of the sawdust on ambient air quality

In examining the effect of saw dust on the ambient air quality of the market, field survey was carried out with the aid of Air Quality Monitor instrument to monitor the level of emission in the study area, its also make use of GPS to show the location sample.

3.5.3 To examine the effect of sawdust on soil and water within the Dei-Dei market

Soil sample will be collected and subjected to laboratory analysis; soil quality parameter were used in order to detect any effect of saw mill operation on the soil of the study area

3.5.4 Access the health implication of sawdust within the Dei-Dei market

The health implication of the saw dust was assessed through the use of questionnaire and health records from the surrounding health facilities within the study area. Health records were collected from surrounding health care facilities and analysis the most frequency illness and correlate it with the effect of saw dust.

Table 3.1: Summary of Materials and Methods

Objectives	Source of Data	Types of Data	Statistical Analysis
To identify sawdust generation and disposal techniques in Dei-Dei market	Field Survey, Personal observation and use of structural questionnaire	Quantity of sawdust waste generation, disposal and storage techniques	Descriptive statistic using frequency
To examine the effect of the sawdust on ambient air quality	Field survey using Portable Air Quality Monitor and GPS	Air Quality	ANOVA analysis
To examine the effect of sawdust on soil and water within the Dei-Dei market	Field survey, soil and water sample	Soil and water test	ANOVA analysis
Access the health implication of sawdust within the Dei-Dei market	Field survey, structural questionnaire health care facility	Health records	Frequency and inferential statistics

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

This chapter deals with the presentation, analysis and interpretation of the data collected in the course of carrying out this study. The presence of data makes no meaning to anybody unless adequate analysis of such data is carried out. The research is based on the analysis of questionnaires, field survey, and interview and laboratory test.

4.1 Sawdust Generation and Disposal Generation in Dei-Dei Market

4.1.1 Waste generated in the Sawmill

Waste generated techniques was examined, it was discovered that 7% of the respondents said less than 10kg of saw waste is being generated daily in their stand; 17% of the respondents said 20-50kg were generated; 26% of the respondents said 60-80kg were generated while higher percentage of the respondents 48% said above 100kg of waste are being generated daily.

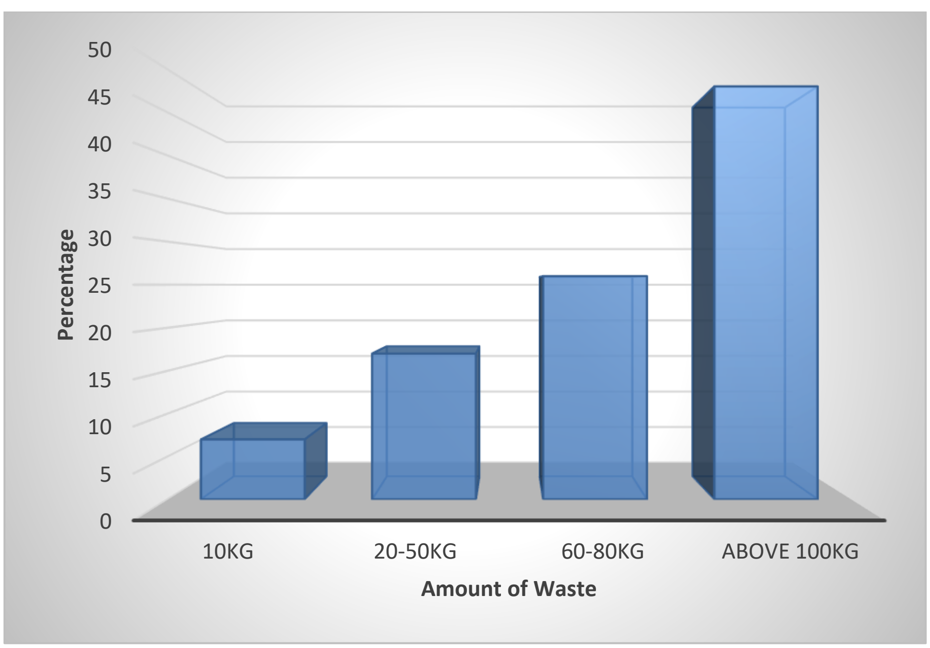

Figure 4.1: Amount of Waste Generated

Plate I: Waste generated in Dei-Dei Timber Market

4.1.2 Waste disposal methods

Table 4.1 shows methods of waste disposal in Dei-Dei market, it was discovered that 15.56% of the respondents have wood waste dump site for disposal by burning, 48.45% of the respondents has heap waste within the open spaces and burn on daily bases, 18.77% of the respondents has Local food vendors and villagers pack for domestic use, 9.38% of the respondent's disposal for agricultural uses and animal bedding while 7.8% of the respondents other means of disposal apart from above.

Table 4.1: Method of Waste Disposal

Waste Disposal Method	Frequency	Percentage
Have wood waste dump site for disposal by burning	50	15.56
Heap waste within the open spaces and burn on daily bases	155	48.45
Local food vendors and villagers pack for domestic use	60	18.77
Disposal for agricultural uses and animal bedding	30	9.38
Other means of disposal apart from above	26	7.82
TOTAL	**321**	**100**

4.2 Effect of Sawdust on Ambient Air Quality

In the first level of analyses, linear and logistic models were applied for the pollutant gases combined to know whether associations exist. The test of homogeneity in mean variance of the concentration levels of the monitored gases across the sampling stations was conducted with analysis of variance (ANOVA). The interactions of these gases were explored with the Spearman Product Moment Correlation Coefficient (r). The Pollutant Standards Index (PSI) was calculated for an overall assessment of air quality within the area following the procedure adopted by Masters (2006).

Table 4.2: Air Quality Parameter

Parameter (ppm)	Min (ppm)	Max (ppm)	Range (ppm)	Mean (ppm)	SE (ppm)	FEPA standard (ppm)
NO_2	0.01	1.33	1.32	0.16	0.009	0.053
SO_2	0.0	0.40	0.40	0.14	0.006	0.05
H_2S	0.03	0.80	0.77	0.43	0.009	0.008
CO	0.60	26.00	25.40	10.73	0.358	10.0
VOC	0.30	11.20	10.90	1.17	0.134	-
CI	0.20	1.50	1.30	0.46	0.009	0.03
PM_{10} (ug/m_3)	0.20	21.60	21.40	9.23	0.311	150
CO_2	80.00	400.00	220.00	249.45	5.058	
HCN	0.20	2.00	1.98	0.82	0.327	0.1
Temp.($_0$C)	23.00	33.00	10.00	27.99	0.167	-
RH(%)	37.00	90.00	53.00	53.99	0.835	-
WS (ms^{-1})	0.20	2.75	2.55	1.25	0.033	-

SE= Standard Error, WS= Wind Speed

There were both wide and narrow variations in the diurnal concentration levels of air pollutants monitored in the area. Nitrogen dioxide (NO_2) ranged from 0.01 to 1.33ppm (0.16 ± 0.009), SO_2 varied from 0.01 to 0.40ppm (0.14 ± 0.006); H_2S varied from 0.03 to 0.80ppm (0.4 ± 0.009), while CO ranged between 0.60 and 26.00ppm (10 ± 0.358). It was further observed that the diurnal concentration levels of VOCs varied between 0.30 and 11.20ppm (1.17 ± 0.134); Cl_2 came between 0.20 and 1.50ppm (0.46 ± 0.009); CO_2 range from 80.00 and 400ppm (249 ± 5.058); HCN between 0.20 and 2.00ppm (0.82 ± 0.327) and PM_{10} varied from 18.5 to 65.6µg/m3 (48.2 ± 13.1). The ambient temperature ranged between 23 and 330C (27.79 ± 0.167) while relative humidity ranged from 37% to 90% (53 ± 0.83) and wind speed between 2.3 and 3.5ms-1 (2.8 ± 0.5) as indicated in Table 4.3.

Several air pollutants exerted significant influences on one another. At $p<0.01$, NO_2 correlated positively with SO_2 (0.42), with CO (0.37), with CO_2 (0.30) and with VOCs (0.75) at $p < 0.05$. In the same vein, SO_2 showed correlation property with H_2S (0.50), CO_2 (0.42) and HCN (0.56) at $p<0.01$. CO correlated positively with HCN (0.52), CO_2 (0.44) and with VOCs (0.22) at $p<0.01$. Also, CO_2 showed positive association with HCN (0.54) as PM_{10} did with CO_2 (0.28) at $p<0.01$. Some negative correlations were observed between some of these air pollutants and shown in Table 4.4 For example, NO_2, correlated negatively with RH (-0.95); PM_{10} with RH (-0.37). The test of homogeneity in mean variance using the single factor ANOVA revealed significant inequality as $F(15.79) > F(3.87)$ at $p<0.05$.

Table 4.3: Correlation Matrix of Ambient Air Pollutants

	NO_2	SO_2	H_2S	CO	VOC	Cl_2	SPM	CO_2	HCN	TEMP	Humidity
SO_2	0.424**										
H_2S	0.370**	0.504**									
CO	0.303**	0.481**	0.488**								
VOC	0.75	0.166*	0.050	0.224**							
NH_3	0.327**	0.435**	0.308**	0.428**	0.213**						
CL_2	0.167**	0.300**	0.339**	0.283**	0.200**						
SPM	0.231**	0.183**	0.213**	0.223**	-0.059	0.247**					
CO_2	0.303**	0.422**	0.445**	0.442**	0.186**	0.300**	0.278**				
HCN	0.347**	0.564**	0.541**	0.520**	0.216**	0.323**	0.116	0.544**			
Temp	0.127*	0.133*	0.202**	0.181**	0.073	0.096	0.188**	-0.040	0.163*		
Humidity	-0.195	-0.215**	-0.345**	-0.251**	-0.116	-0.123	-0.374**	-0.48	-0.154*	-0.702**	
Ws	-0.171**	-0.305**	-0.336**	-0.334**	-0.098	-0.179**	-0.002	-0.166*	-o.315**	-0.33*	-0.126

*** = significant at p<0.05, ** = significant at p<0.01, WS = Wind speed**

4.3 Effect of Sawdust on Soil and Water in Dei-Dei International Timber Market

4.3.1 Effect sawdust on soil

The average concentration of heavy metals in soil samples collected at five selected points in Dei – Dei sawmills sites are presented in Tables 4.4- 4.8. All the metals investigated were found to be present in the soil samples. Coefficient of variation values for most examined metals revealed no significant difference among sampling points. This might be due to the fact that the waste generated by the sawmill industries are almost the same in composition. The levels (mg/kg) of Co, Cr, Mn, Pb, Cd, Cu, Fe, Ni and Zn at various sampling points from all the sites ranged from 0.40-1.69, 0.68-3.34, 0.24-1.74, 0.28-7.32, 0.07-0.47, 0.76-3.54, 5.58-18.67, 0.06-0.30, 9.19-3.58 respectively.

Table 4.4: Soil Sampled at Site I

Sample code	Co	Ni	Cu	Zn	Pb	Mn	Cd	Fe	Cr
A_{11}	1.19	0.12	1.46	5.33	1.65	1.03	0.28	9.67	1.30
A_{12}	0.85	0.10	1.30	4.93	1.47	0.89	0.24	9.34	1.16
A_{21}	1.06	010	1.21	5.08	1.37	0.94	0.25	8.32	1.08
A_{22}	0.77	0.08	1.03	4.16	1.16	0.81	0.22	8.16	0.92
A_{31}	0.83	0.08	1.01	4.54	1.14	0.75	0.22	8.14	0.90
A_{32}	0.50	0.08	0.98	3.94	1.10	0.49	0.13	7.36	0.87
A_{41}	0.63	0.07	0.89	4.11	0.94	0.70	0.19	7.24	0.79
A_{42}	0.40	0.06	0.76	3.91	0.86	0.57	0.15	6.58	0.68
Mean	0.78	0.09	1.08	4.50	1.21	0.77	0.21	8.10	0.96
S.D	0.25	0.02	0.21	0.52	0.25	0.17	0.05	0.98	0.23
C.V	32.00	25.00	20.00	12.00	21.00	22.00	23.00	12.00	24.00

S.D. = Standard Deviation, C.V= Coefficient of Variation = soil samples at 20cm depth A_{11}, A_{21}, A_{31}, A_{41}= soil samples at 5cm depth.

Table 4.5: Soil Sampled at Site II

Sample code	Co	Ni	Cu	Zn	Pb	Mn	Cd	Fe	Cr
B_{11}	1.18	0.16	1.96	6.47	2.22	1.10	0.30	10.66	1.75
B_{12}	1.14	0.14	1.79	6.14	2.02	1.03	0.28	9.88	1.59
B_{21}	1.08	013	1.61	5.92	1.82	1.05	0.29	10.70	1.44
B_{22}	0.87	0.12	1.51	5.03	1.71	0.87	0.24	9.79	1.35
B_{31}	0.81	0.11	1.41	4.85	1.32	0.81	0.22	8.23	1.26
B_{32}	0.77	0.08	1.01	4.06	1.14	0.74	0.20	7.91	0.90
B_{41}	0.76	0.09	1.09	3.76	1.23	0.65	0.18	7.28	0.97
B_{42}	0.62	0.06	0.79	3.58	0.89	0.42	0.11	5.58	0.70
Mean	0.90	0.11	1.40	4.98	1.54	0.83	0.23	8.77	1.25
S.D	0.19	0.03	0.38	1.05	0.44	0.22	0.06	1.70	0.34
C.V	21.00	28.00	27.00	21.00	28.00	26.00	27.00	19.00	27.00

Table 4.6: Soil Sampled at Site III

Sample code	Co	Ni	Cu	Zn	Pb	Mn	Cd	Fe	Cr
C_{11}	0.80	0.17	2.11	6.30	2.38	0.93	0.25	12.30	1,88
C_{12}	0.60	0.15	1.89	5.97	2.14	0.85	0.23	11.99	1.69
C_{21}	0.58	0.16	2.02	5.52	2.05	0.81	0.22	11.15	1.54
C_{22}	0.52	0.14	1.72	5.06	1.95	0.08	0.22	10.57	1.54
C_{31}	0.57	0.13	1.58	5.03	1.78	0.67	0.18	10.46	1.41
C_{32}	0.41	0.11	1.36	4.82	1.54	0.53	0.14	9.67	1.22
C_{41}	0.55	0.10	1.29	4.90	1.46	0.49	0.12	9.00	1.16
C_{42}	0.39	0.07	0.88	4.45	0.99	0.45	0.12	8.17	0.79
Mean	0.55	0.13	1.61	5.26	1.79	0.69	0.19	10.41	1.11
S.D	0.12	0.03	0.39	0.58	0.42	0.17	0.04	1.33	0.34
C.V	21.00	25.00	24.00	11.00	23.00	25.00	23.00	13.00	24.00

Table 4.7: Soil Sampled at Site IV

Sample code	Co	Ni	Cu	Zn	Pb	Mn	Cd	Fe	Cr
D_{11}	1.22	0.21	2.61	6.78	2.41	1.15	0.28	18.67	2.33
D_{12}	1.18	0.17	2.11	6.85	2.38	1.00	0.27	13.17	1.88
D_{21}	1.33	0.18	2.27	6.73	2.56	0.94	0.25	12.29	2.02
D_{22}	1.31	0.15	1.89	6.66	2.14	0.93	0.25	11.89	1.69
D_{31}	1.31	0.18	2.22	6.47	2.51	0.93	0.25	11.36	1.98
D_{32}	1.02	0.16	1.97	5.76	2.23	0.75	0.20	10.71	1.76
D_{41}	1.08	0.16	1.96	6.24	2.22	0.51	0.14	9.50	1.75
D_{42}	0.99	0.14	1.71	5.92	1.94	0.24	0.07	8.87	1.53
Mean	1.18	0.17	2.09	6.43	2.30	0.81	0.21	12.06	1.87
S.D	0.13	0.02	0.26	0.39	0.19	0.39	0.07	2.83	0.23
C.V	11.00	11.00	12.00	6.00	8.00	49.00	32.00	24.00	12.00

Table 4.8: Soil Sampled at Site V

Sample code	Co	Ni	Cu	Zn	Pb	Mn	Cd	Fe	Cr
E_{11}	1.69	0.16	2.06	9.19	7.32	1.74	0.47	14.70	1.84
E_{12}	1.50	0.28	3.54	8.89	6.00	1.39	0.38	13.47	3.16
E_{21}	1.34	0.25	3.08	8.48	6.48	1.14	0.31	14.93	2.75
E_{22}	1.33	0.27	3.35	8.36	4.78	1.00	0.27	13.91	2.99
E_{31}	1.31	0.30	3.75	7.89	5.23	0.97	0.26	14.26	3.34
E_{32}	1.28	0.19	2.41	7.82	2.72	0.87	0.24	13.24	2.15
E_{41}	1.31	0.19	2.36	8.27	2.67	0.75	0.20	16.18	2.11
C_{42}	0.99	0.09	1.16	7.72	1.31	0.50	0.13	15.09	1.04
Mean	1.35	0.22	2.71	8.33	4.56	1.05	0.28	14.47	2.42
S.D	0.19	0.07	0.80	0.49	1.98	0.36	0.10	0.I91	0.72
C.V	14.00	31.00	29.00	6.00	43.00	34.00	34.00	6.00	31.00

The consistently high load of iron recorded in all the sites is not surprising considering the fact that iron is one of the constituents (alloy) of the saws used in sawmill operations or wood processing. The wear and tears of the saws and other metal equipment used might have contributed to the concentration of this metal when compared with other metals in this research work.

The relatively low average content of the metals investigated in this study present insignificant exposure risks. This does not rule out the possibility of increase in concentration of this metals with time, since, the extent of heavy metal pollution varies with age. The concentration of the heavy metal levels in the soil suggests that these metals are of natural origin with contribution from anthropogenic influences. The level of Pb and Cd contents shows that the soil around this site is moderately polluted. Hence, the cumulative effect through bio-accumulation might be of concern in future, thus calling for urgent attention on regular monitoring of the sawmill activities and its influence on the surrounding environment.

4.3.2 Effect of sawdust on water quality

Table 4.9 summarises the mean values of the various parameters monitored at the three selected sample point. Water temperatures and Total alkalinity were the only parameters that were not statistically significant in the three sampled site. Water depth, Transparency, Flow velocity, Conductivity, pH, Dissolved oxygen, BOD Phosphate and Nitrate showed variations in the three sites sampled and was statistically significant ($P<0.05$). Air and water temperatures were in the range of 24-31°C in the three sites sampled and were not significantly different from each other.

Table 4.9: Physicochemical parameter of the study sites (Minmium, Maximum values in parentheses values are: Mean$\pm$SE

Table 4.9: The Mean Values of the Various Parameters Monitored at the Three Selected Sample Point

Parameter	Sample 1	Sample 2	Sample 3	F. value ANOVA	P
Air temperature(ºC)	26.93±1.09	26.67±0.99	26.80±1.33	0.09	(p>0.05)
	(25.60-28.6)	(2.53-28.1)	(25.00-28.4)		(p>0.05)
Water temperature (ºC)	25.70±2.12	25.70±1.26	25.50±2.39	0.07	
	(24.20-28.0)	(24.20-27.4)	(24.00-27.2)		(p>0.05)
Water depth (m)	1.57±0.006	1.20±0.03	1.40±0.03	5.11	
	(1.20-1.80)	(1.00-1.40)	(1.20-1.60)		(p>0.05)
Transparency (m)	0.94±0.11	0.33±0.004	0.92±0.06	11.76	
	(0.60-1.30)	(0.25-0.42)	(0.64-1.20)		
Flow velocity(ms^{-1})	0.47±0.006	0.24±0.006	0.38±0.012	10.09	(p>0.05)
	(0.33-0.54)	(0.11-0.33)	0.22-0.04		
Conductivity (usm^{-1})	28.18±10.6	210.00±21.82	20.67±2.36	89.91	(p>0.05)
	(20.30-43.8)	(162.00-274.1)	(14.80-28.6)		
pH	7.30±0.18	6.63±0.15	7.27±0.53	4.67	(p>0.05)
	(7.20-7.9)	6.00-7.0)	(6.40-7.8)		
Dissolved oxygen (mg1^{-1})	6.75±0.18	3.78±0.44	8.06±0.53	74.55	(p>0.05)
	(6.00-7.10)	(3.20-4.48)	(7.49-4.36)		
BOD$_5$ (mg1^{-1})	2.85±1.16	13.67±8.67	2.85±0.50	67.99	(p>0.05)
	(1.45-4.5)	(12.00-18.0)	(2.00-4.00)		
Alkalinity (mg1^{-1})	2.67±0.024	2.82±0.15	2.88±0.016	3.62	(p>0.05)
	(2.48-2.86)	(2.67-3.00)	(6.67-3.00)		
Phosphate (mg1^{-1})	0.065±0.0011	0.83±0.017	0.058±0.0014	180.5	(p>0.05)
	(0.030-0.12)	(0.60-0.98)	(0.01-0.11)		
Nitrate (mg1^{-1})	0.058±0.003	0.49±0.008	0.085±0.014	114.26	(p>0.05)
	(0.020-0.15)	(0.20-0.61)	0.0050-0.33)		

Note: * indicate significant differences at a probability level of 5%

Conductivity values were significantly different among the sites sampled (P<0.05) the impacted site (site 2) recorded high conductivity values throughout. Similarly, transparency measured in metres was significantly different in the different sites (P<0.05). Again, the sawmill deposit reduced drastically the rate of penetration of light to the bottom. Most of the chemical variables, that is dissolved oxygen, BOD5, Total alkalinity, Hydrogen ion concentration (pH), Nitrate-nitrogen (N03-N), Phosphate-phosphorus (Po4-p) all measured in mg l 1, were significantly different among the various stations sampled ($P<0.05$). Orthogonal comparison using Duncan's multiple range test showed that sites 2 (impacted site) was the cause of the observed differences in these parameters.

4.4 Health Implication of Sawdust

Figure 4.2 shows that, 3.3% sawmill workers and 4.2% inhabitants of the environment signified that they had knowledge and experiences of the impact of sawmill operation on health. While a greater proportion of 42.5% sawmill workers and 50% inhabitants of the Environment said that they never had knowledge and experience of the impact of sawmill operation on health. This is similar to Theodore and Hattington (1981) as stated by Amunega (2002), who said there is lack of adequate knowledge and experience about the importance of health education within industry.

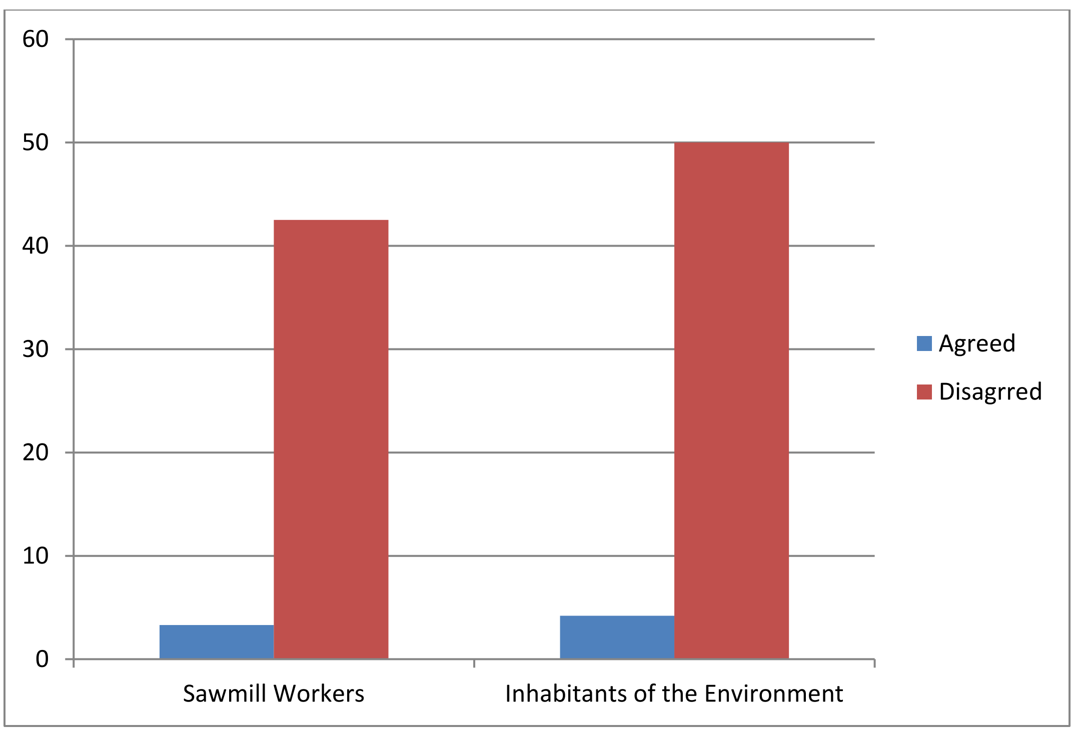

Figure 4.2 Knowledge and experience of the health impact of saw mill operations

4.4.1 Diseases contracted in sawmills operations

Awareness of diseases contracted in sawmills that can affect health by sawmill workers and the inhabitant of the residential areas Table 4.10 shows that 40.8% sawmill workers and 39.2% inhabitant of the residential areas agreed that they were aware that headache can be contracted in the sawmill due to noise pollution, while 37% of sawmill workers and 42.5% inhabitant of the residential areas agreed to body pains/fever. This is similar to a study conducted by Adegbenro and Fabiyi (2002) who observed that headache /fever topped the list of health problems experienced by the workers with 90% in industry. A total of 39.2% sawmill workers and 40% inhabitant of the residential areas signified that hearing problem can be contracted due to excessively loud noise. This is contrary to Adegbenro and Fabiyi (2002) who observed that only 25% out of 100% of the industrial workers experienced hearing problem. But in line with Awake
(2001), who stated that noise pollution does negatively affect human being and the environment. None of the respondents both from the sawmill workers and inhabitant of the residential areas agreed that cancer risks can occur due to sawmill wastes.

Table 4.10: Awareness of Disease Contracted in Sawmills that can Affect Health of Sawmill Workers and Inhabitant of the Residential Areas

Variables	Sawmill workers		Inhabitant of the residential areas	
	Agreed%	Disagreed %	Agreed%	Disagreed%
Headache	8%	5%	39.2%	15%
Respiratory illness	35.8%	10%	8.4%	45.8%
Cardio-vascular illness,	20%	25.8%	5.8%	48%
Cough	29.6%	16.25%	41.7%	12.5%
Cancer risk	0%	45.8%	0%	54.2%
Stomach upset/nausea	19.2%	26.7%	10%	44.2%
Skin irritation	33.8%	12.1%	10.4%	43.8%
Eye problem	10.8%	35%	7.9%	46.3%
Body pains/ fever	37%	8.8%	42.5%	11.7%
Hearing problem	39.2%	6.7%	40%	14.2%

4.5 Summary of Findings

It was discovered that 7% of the respondents said less than 10kg of saw waste is being generated daily in their stand; 17% of the respondents said 20-50kg were generated; 26% of the respondents said 60-80kg were generated while higher percentage of the respondents 48% said above 100kg of waste are being generated daily. The study shows that 15.56% of the respondents have wood waste dump site for disposal by burning, 48.45% of the respondents has heap waste within the open spaces and burn on daily bases, 18.77% of the respondents has Local food vendors and villagers pack for domestic use, 9.38% of the respondents disposal for agricultural uses and animal bedding while 7.8% of the respondents other means of disposal apart from above.

In the first level of analyses, linear and logistic models were applied for the pollutant gases combined to know whether associations exist. The test of homogeneity in mean variance of the concentration levels of the monitored gases across the sampling stations was conducted with analysis of variance (ANOVA). The interactions of these gases were explored with the Spearman Product Moment Correlation Coefficient (r). The Pollutant Standards Index (PSI) was calculated for an overall assessment of air quality within the area following the procedure adopted by Masters (2006).

Several air pollutants exerted significant influences on one another. At $p<0.01$, NO2 correlated positively with SO2 (0.42), with CO (0.37), with CO2 (0.30) and with VOCs (0.75) at $p < 0.05$. In the same vein, SO2 showed correlation property with H2S (0.50), CO2 (0.42) and HCN (0.56) at $p<0.01$. CO correlated positively with HCN (0.52), CO2 (0.44) and with VOCs (0.22) at $p<0.01$. Also, CO2 showed positive association with HCN (0.54) as PM10 did with CO2 (0.28) at $p<0.01$.

The average concentration of heavy metals in soil samples collected at five selected points in Dei – Dei sawmills sites. All the metals investigated were found to be present in the soil samples. Coefficient of variation values for most examined metals revealed no significant difference among sampling points. This might be due to the fact that the waste generated by the sawmill industries are almost the same in composition. The levels (mg/kg) of Co, Cr, Mn, Pb, Cd, Cu, Fe, Ni and Zn at various sampling points from all the sites ranged from 0.40-1.69, 0.68-3.34, 0.24-1.74, 0.28-7.32, 0.07-0.47, 0.76-3.54, 5.58-18.67, 0.06-0.30, 9.19-3.58 respectively.

The relatively low average content of the metals investigated in this study present insignificant exposure risks. This does not ruled out the possibility of increase in concentration of this metals with time, since, the extent of heavy metal pollution varies with age. The concentration of the heavy metal levels in the soil suggests that these metals are of natural origin with contribution from anthropogenic influences. The level of Pb and Cd contents shows that the soil around this site is moderately polluted. Hence, the cumulative effect through bio-accumulation might be of concern in future, thus calling for urgent attention on regular monitoring of the sawmill activities and its influence on the surrounding environment.

The findings shows mean values of the various parameters monitored at the three selected sample point. Water temperatures and Total alkalinity were the only parameters that were not statistically significant in the three sampled site. Water depth, Transparency, Flow velocity, Conductivity, pH, Dissolved oxygen, BOD Phosphate and Nitrate showed variations in the three sites sampled and was statistically significant ($P<0.05$). Air and water temperatures were in the range of 24-31°C in the three sites sampled and were not significantly different from each other.

Conductivity values were significantly different among the sites sampled ($P<0.05$) the impacted site (site 2) recorded high conductivity values throughout. Similarly Transparency measured in metres was significantly different in the different sites ($P<0.05$). Again the sawmill deposit reduced drastically the rate of penetration of light to the bottom. Most of the chemical variables, that is dissolved oxygen, BOD5, Total alkalinity, Hydrogen ion concentration (pH), Nitrate-nitrogen (N03-N), Phosphate-phosphorus (Po4-p) all measured in mg l 1, were significantly different among the various stations sampled ($P<0.05$). Orthogonal comparison using Duncan's multiple range test showed that sites 2 (impacted site) was the cause of the observed differences in these parameters.

The findings also show the awareness of diseases contracted in sawmills that can affect health by sawmill workers and the inhabitant of the residential areas, it shows that 40.8% sawmill workers and 39.2% inhabitant of the residential areas agreed that they were aware that headache can be contracted in the sawmill due to noise pollution, while 37% of sawmill workers and 42.5% inhabitant of the residential areas agreed to body pains/fever.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.2 Conclusion

The following conclusions were made based on the investigation conducted in the industry:

The categories of workers in sawmill industries acquired their skills and expertise from their practical experience during the job period. However, the professional knowledge regarding safety approach of their work were lacking. Attentions to safe work environment and organization were not adequate. Also, the appropriate tools were not available to carry out effective routine maintenance. Most operations carried out in the mills were largely supported by manual handling which often result to overexertion and a long term health hazards. Personal protection devices such as earmuff or plug, hand gloves were not used adequately and were often considered as irrelevant and disturbing. Dust and wood wastes were not properly disposed which was evident from heaps of wood shavings and saw dust accumulation around milling machines.

Finally, it was observed that none of the companies had any safety policies, materials, etc. in place, but a reliance on workers responsibility to provide the appropriate personal protection device, to have a safe working environment. Focus should be on these challenges in practical terms to form a safety legislation, comprehensive systems approach and monitoring group in the industry to guide the management in the implementation order to reduce or eliminate workplace hazards

5.2 Recommendations

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

1. Measures such as the identification of hazards that are associated with wood dust and other substances in wood-based industries should guide the workers in planning for processing activities in order to eliminate hazards.
2. An attempt should be made by the government to formulate an appropriate policy for wood-based industries in order to avoid the misuse of chemicals.

3 Measures such as the delegation of authority in wood processing industries to develop the subordinate potentials and job satisfaction, motivation of workers in industries through the provision of adequate working materials and development should be employed by the management levels of wood processing industries for co-ordination of processing activities

4. An attempt should be made by the government and management levels to identify the major constraints hindering the management of occupational hazards in wood processing industries. The identification of hazards can help them to determine the control measures.

5. Measures such as the training of employees to recognize, avoid and correct potentially hazardous conditions should be adopted by all the workers for improving the management of occupational hazards if the objectives of wood processing industries are to be achieved

6 Saw mill workers should be trained in computer applications which could enable them operate any computerized equipment. This can be done by including computer applications to the curriculum of any institution running programmes in wood technology. This can be beneficial in future as woodworking technology becomes sophisticated as more industries install computer equipment.

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