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Original Paper

Impact of Sawmill Industry on Ambient Air Quality: A Case Study of Ilorin Metropolis, Kwara State, Nigeria

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Abstract

Amid sawmill busy lives, air pollution is one of the greatest casualties of our time and has increased worldwide since 1990. Today, the history of air pollution in sawmills accounts for 93.32% of the total number of wood processing industries in Nigeria, it seems daunting, overwhelming and have positioned the country at a perilous crossroad. For emerging nations such as Nigeria with a population projected to hit 410.6 million humans by 2050 with up to 40-60 million people with mental disorders at the moment, consequently more than 40,000 deaths a year will be due to air pollution. 7 million deaths worldwide is attributed to air pollution with the number set to increase significantly in coming decades mostly through non-communicable diseases like lung cancer, stroke and chronic obstructive pulmonary disease but also through acute respiratory infections like pneumonia. Similarly, around 90% of all people breathe air contaminated with pollutants. In 2015, tobacco caused 7 million deaths, 1.2 million AIDS, 1.1 million cases of tuberculosis and 0.7 million of malaria, 19% of all cardiovascular deaths, 24% of all deaths due to ischaemic heart disease. 21% of stroke deaths, and 23% of deaths from lung cancer. Non-communicable diseases are responsible for 70% of deaths from air pollution and are a major cause of unexplained infections. In addition, air pollution seems to be significant but it is still not a determinant factor of the risk of neurodegenerative disorders in children and neurodegenerative diseases in adults. This study assessed ambient air quality in major sawmill sites in Ilorin Metropolis, *Kwara State, Nigeria. Air pollution measurements were made using direct reading through automatic in situ gas monitors; Hand held mobile multi-gas monitor with model AS8900 (Combustible (LEL), and Oxygen (O_2)), BLATN with model BR—Smart Series air quality monitor (PM_{10}, Formaldehyde) and air quality multimeter with model B SIDE EET100 (Dust ($PM_{2.5}$), VOC, Temperature and Relative Humidity). The results show that the mean concentrations of CO, O_2 and other measured parameters such as Formaldehyde (HcHo) etc., are commonly lower and within acceptable range of National and International regulatory standards for air quality indices. There are however some exceptions such as mean concentrations of Volatile Organic Compounds (VOCs), $PM_{2.5}$, PM_{10} and Combustible (LEL) respectively high when compared to National and International standards. This high value is attributed to the amount of pollutant present in the sawmills due to the input of influents it receives from activities of the sawmill. This is why there has been air pollution in Ilorin metropolis and were however, found to be polluted. Given the high cost of additional measures to lessen air pollution and the new perspectives suggesting that health effects can be observed at low concentrations, the health effects of air pollution should be of scientific and regulatory interest in coming years. In the absence of aggressive control, ambient air pollution is expected to cause between 6 and 9 million deaths a year by 2060.*

Keywords

Non-communicable diseases, Quantified risk factor, Neurodevelopmental disorders, Neurodegenerative diseases, Acute Lower Respiratory Infection (ALRI), Mental disorders, Sawmills

1. Background of the Study

High levels of air pollution are a known risk factor for child health, particularly childhood pneumonia and still remains at dangerously high levels to the health of the environment and have significant immediate effects, especially around the sawmill. The snag, however, is that the rapid development recorded in the building construction sector is the result of high proliferation in the setting up of sawmills in several fragments of the country to satisfy the mounting wood demand, its activities and processes in the sawmill industry. They yield both well-known and unknown gaseous contaminants that are released into the atmosphere that can be hazardous to public health. Report from World Health Organization shows that in 2016 nearly one in five deaths attributed to ambient air pollution were caused by acute lower respiratory infections meaning 18% were ascribed to Acute Lower Respiratory Infection (ALRI) and recent studies reported that even short-term exposure to air pollution can cause ALRIs, making the body more prone to infection or less able to fight it. Research has revealed nasal cancer and asthma are highly associated with continuous exposure to wood dust and other substances used in the wood industry (Anavberokhai, 2008). The short-term deleterious health effects of air pollution exposure are well documented (Ruckerl et al., 2011; Heroux et al., 2015; Raimi et al., 2018). Air pollution, especially Particulate Matter (PM), poses public health problems due to its toxicity and the widespread human exposure to this pollutant. PM, including aerodynamic diameter with inhalable particles below or equal to 10 µm (PM_{10}) and fine particles of an aerodynamic diameter equal to or below 2.5 μm ($PM_{2.5}$), are emitted by combustion sources or are formed by transformation of atmospheric chemistry. Given evidence of health effects, average daily and annual concentrations of PM_{10} and $PM_{2.5}$ are regulated in accordance with air quality guidelines (World Health Organization, 2006) and in major countries. All over the world, both developed and developing countries, the health risk of urban dwellers due to particulate matter are well documented (Wilson & Spengler, 1996; Raimi et al., 2018). To estimate health damage associated with air pollution in emerging countries such as Nigeria, policy makers are often forced to extrapolate results from studies in industrialized countries. However, these extrapolations may be inappropriate for two reasons. First, it is not clear that the relationship between pollution and health at relatively low levels of pollution in industrialized countries applies to the extremely high levels of pollution found in developing countries. For example, particulate matter levels are often three to four times higher in developing countries than in industrialized countries. Secondly, people in developing countries like Nigeria die earlier and for reasons other than those in industrialized countries, suggesting that extrapolating the air pollution effects on mortality can be particularly misleading. Schematically, in an increasingly complex industrial society, increasing attention is being paid to technological risks replacing natural hazards as the greatest environmental threat to human life and property. Because economic development is crucial to urban development and growth, economic development has not only brought growth and prosperity, but ultimately economic decline and environmental problems have also affected the regions. Rapid urbanization and industrialization have increased the vulnerability of individuals to various man-made dangers. For most people, the real threat is experienced indirectly. However, a significant number of people are directly confronted with an unhealthy environment simply because of their geographical location, living in an area where the real hazards occur. This is the case with residents of the major saw mills in Ilorin, Kwara State, Nigeria.

Within the major sawmills, the proximity of sawmills industry and housing has created a certain amount of controversy about the environmental quality. Residents' right to enjoy the benefits of clean air is limited by the activities of the timber industry. As a result, concerns are raised about the impact of pollution on health. At least a quarter of the world's population is exposed to the risk of air pollution (WHO, 2006), and the loss of nearly 6.4 million years of a healthy life is associated with chronic exposure to ambient particulate matter (WHO, 2006; Raimi et al., 2018; Raimi et al., 2019). Expert panels for the U.S. Environmental Protection Agency, United Nations, and other agencies have consistently *cited* air pollution as a greater health hazard than water pollution (Freeze, 2000). Both Particulate Matter (PM) and ozone (O_3) are associated with a number of deleterious effects on human health, and in fact there is no threshold that has been established under which these pollutants exert no adverse effects (Daniel, 1989; WHO, 2006; Bell et al., 2013). What we do not know is the difference in the amount of air pollutants concentrations within sawmill environment. Do the levels of air pollution vary significantly within sawmill environment and, if so, is there a pattern to such variability?

Pollution has become one of the major threats to global health and existential challenges of the 21st century and 4th industrial revolution with more than 90% of the deaths occuring in low and middle income countries, mainly in Asia and Africa but also in the Eastern Mediterranean, Europe and the Americas. Despite changes in climate, loss of biodiversity, acidification of the ocean, drought and desertification, and global fresh water supply depletion, earth's support systems and its sustainability is endanged by pollution and threatens the current existence of human societies and its association (Rockstrom et al., 2009). Health effects of air pollution will affect many communities in the coming years and endanger the lives and wellbeing of billions of people at increased risk. Pollution, particularly vehicular exhausts, emissions from industries and toxic chemicals, has significantly increased over the past 500 years, and are considered the largest increase in emerging countries today. Yet despite its great and mounting magnitude of vehicular, industrial and pollution from chemical in emerging countries has been principally overlooked in global development and international health agenda, and pollution control programmes have shown little attention or resources from either global agencies or development partners, i.e., philanthropic donors. Currently, pollution has become a major problem that threatens the health of billions, worsens the Earth's ecosystems, weakens the economic security of the country, and is accountable for a vast worldwide burden of disease, disability, and premature death. Pollution is closely associated with global climate change (McMichael et al., 2017; Perera, 2017). Combustion of fossil fuel in developed and middle-income nations, and biomass burning in inefficient cook stoves, open fires, agricultural burns, forest burning, sawmill activities and outdated brick kilns in emerging countries are responsible for 85% of airborne pollution particulate and for nearly all oxides of sulphur and nitrogen pollution. Combustion of fuel is a main source of greenhouse gases and short-lived pollutants due to climate that are the key anthropogenic drivers of human climate change (Gaveau et al., 2015; Johnston et al., 2012; Scovronick et al., 2015).

Pollution is expensive; it is held responsible for productivity losses, costs of health-care and associated costs from ecosystems damages. Regardless of the great extent of these costs, they have not been seen and are not recognised as caused by pollution (National Academy of Sciences, 2010). The productivity losses of pollution-related diseases and health-related costs are buried in labour statistics and in hospital budgets (Landrigan & Fuller, 2015). The pollution consequence is that the complete costs are underestimated and not appreciated, are often not counted, and are not accessible to refute one-sided, against pollution control that are economically based arguments (National Academy of Sciences, 2010; Epstein et al., 2011). The changing nature of air pollution in many places around the world is worsening particularly at sawmill environment. These changes reflect increased consumption of energy, increased usage of novel materials and technologies, the rapid industrialisation of low-income and countries of middle-income and the global populations shift from areas of rural into cities. Air from household and pollution from water are methods of pollution that remained traditionally associated with extreme poverty and historical lifestyles, are slowly declining. However, ambient air pollution, pollution from chemical and land pollution, are all increasing (Smith & Ezzati, 2005; Omran, 2005).

The main causes of this pollutants type remain: the unrestrained development of cities (Wilkinson et al., 2007); increasing demands for energy (Ebuete et al., 2019); increasing mining, smelting, and deforestation (Raimi et al., 2019); the global blowout of toxic chemicals; progressively heavier applications of insecticides and herbicides; and an increasing use of petroleum-powered cars, trucks, and buses. Ambient air increases in soil and chemical pollution over the last 500 years have been linked to the immediate widespread, linear, take-make-use-dispose economic reforms termed by Pope Francis "the throw away culture" (Pope Francis, 2015) in which natural resources and human capital are widely regarded as commercially available and expendable, and the significances of their careless exploitation are given little attention (Whitmee et al., 2015; Raworth, 2017).

The understanding of the science of environmental pollution and its impact on health has made great progress (National Academy of Sciences, 2012; Brauer et al., 2012; Olalekan et al., 2020). New technologies, including satellite imagery (Sorek-Hamer et al., 2016), have improved the capacity to map pollution, detect the level of pollution remotely, detect pollution patterns, and monitor seasonal trends (Brauer et al., 2012). Sophisticated chemical analyses have provided a better understanding of the pollution configuration and revealed the relationship between pollution and disease (Valavanidis et al., 2008; Suleiman et al., 2019). The probability of a major disease being discovered indicates that certain pollutants are associated with a greater number of diseases, particularly non-communicable diseases, than was hitherto known. Pollution is now known to be a significant contributing factor for numerous non-communicable diseases such as neurodevelopmental disorders, asthma, cancer and in children, birth defects with heart disease, stroke, chronic obstructive pulmonary disease and in adults, cancer (Loomis et al., 2013; Thurston & Lippmann, 2015). In the lack of aggressive interference, the level of air pollution mortality rate will increase by more than 50% by 2050 (Lelieveld et al., 2015). Despite these scientific advances, much remains to be said about the effects of the pollution and their public health effects. The shortcomings comprise the lack of evidence in many nations on measures taken to combat pollution and the frequency of pollution-related disease and its effects; poor knowledge of the harmful effects of chemicals on specific public use, especially, novel classes of chemicals (Landrigan & Goldman, 2011; Grandjean & Landrigan, 2014); Insufficient information on the level of exposures and disease burden associated with lethal exposures at contaminated environment and insufficient information to account for the likely overdue effects of lethal exposures continued in the beginning of life (Heindel et al., 2015). The exact dose-response nature of the model used to assess risk of disease linked with air pollution is unknown. For example, with regard to fine-particulate air pollution, the exposure shape response group, both at lower and very high levels of exposure is much less pronounced and the expectations that underlie the integrated exposure response function used to appraise the relative hazards of fine particulate ($PM_{2.5}$) exposure in both the Global Burden of Disease (GBD) study and WHO studies are not exactly known (Burnett et al., 2014; Global burden of Diseases Study, 2015; Cohen et al., 2017).

2. Objectives of the Study

This study aims at assessing major sawmill environment ambient air quality in Ilorin Metropolis, Kwara State, Nigeria.

To achieve this aim, the following specific objectives are to:

i. Examine the relationship among CO (ppm), $PM_{2.5}$ (ug/m^3), PM_{10}(ug/m^3), H_2S (ppm), VOC (ppm), LEL (%), Formaldehyde (mg/m^3), Oxygen (O_2), temperature (O^0C) and relative humidity (RH) in the study area.

ii. Compare air quality with international and national acceptable standards.

iii. Compare the concentrations of CO, $PM_{2.5}$, PM_{10}, H_2S, VOC, LEL, Formaldehyde, Oxygen (O_2), temperature and relative humidity.

iv. Make the necessary recommendations from the findings to the residents of the major sawmills in Ilorin Metropolis, Kwara State, Nigeria.

3. Study Area

3.1 Location

Ilorin, the capital of Kwara State is located on latitude 8º30' and 8º50'N and longitude 4º20' and 4º35'E of the equator (Figure 1), with a population of over one million people (2006 census). Ilorin city occupies an area of about 468 sqkm and it is situated in the transitional zone within the forest and the guinea savannah regions of Nigeria. It is about 300 kilometres away from Lagos and 500 kilometres away from Abuja the Federal Capital of Nigeria. Its elevation ranges from 250 to 400 m above sea level. It is also the headquarters of the Ilorin West Local Government Area (LGA) which is surrounded by other LGAs of the state. This gives her roles as the commercial and administrative capital of the State, the headquarters of Ilorin West LGA, and together with Ilorin East, Ilorin South, Asa and Moro LGAs they constitute the Ilorin Emirate. The location of Ilorin west is shown in Figure 1. Ilorin has diverse ethnic groups of mainly Yoruba, Fulani, Hausa, Kambari, Gobir, and Nupe, that constituted it. The multi-linguistic and multi-cultural nature of the people could be traced to their historical background. Ilorin is said to be founded as hamlets in 17^{th} century by an itinerant farmer called Ojo from Gambe near Oyo-Ile. The hitherto existing hamlets were in 1830s consolidated under the sovereignty of Fulani hegemony by Abdul-Salam, the son of Sheikh Alimi. The total population of Ilorin West LGA is 365,221 in 2006. This is comprised of 180,387 males and 184,834 females; being the most populous LGA in Kwara State that has 3.0% as its growth rate (NPC, 2006).

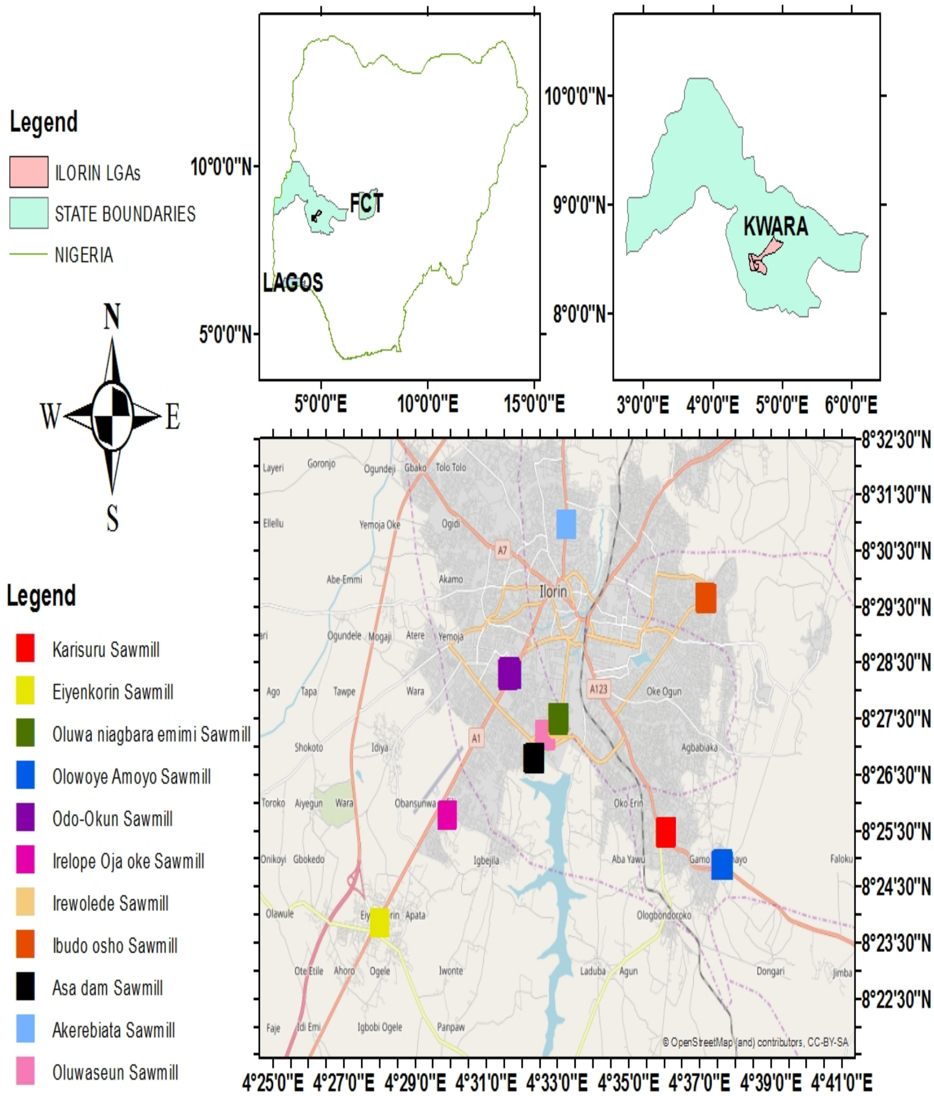

Figure 1. Map of Kwara State Showing the Study Area

3.2 Climate

Ilorin climate is tropical under the influence of the two trade winds prevailing over the country. According to Ifabiyi (1999) and Raimi et al. (2018), the climate of the city of Ilorin is tropical continental with high temperature throughout the year. It is characterised by wet and dry seasons. Ilorin falls within derived savannah vegetation, covered with the existence of dry lowland rain forest vegetation cover. The wet season is between March and October whereas the dry season is between the months of November and February. The total annual rainfall in the state boundary of the north ranges from 800 mm to 1200 mm, in the north western parts of the state and have 950 mm to 1300 mm while in the southeast is 1000 mm to 1500 mm. Kwara state has several rivers which include: river Asa, Awonriver, Oshin and Moro in the central state. Likewise, the monthly mean temperature is generally high throughout the year. The daily average temperatures are in January with 25ºC, May 27.5ºC and

September 22.5ºC. While humidity is relatively moderately high the amount of rainfall in the southern part is relatively higher than what is experienced in the northern part of the studied area.

3.3 Vegetation

The vegetation is mainly within the deciduous woodlands of southern Nigeria and the dry savannah of Nigeria. These are essentially made up of grass cover, shrubs and medium sized trees of the guinea savannah type (Olaniran, 1982; Ileoje, 1985; Raimi et al., 2018). The vegetation of Ilorin is composed of species of plant such as locust beans trees, shear butter trees, elephant grasses, shrubs and herbaceous plant among others are common in this area. The vegetation of the study area has partial rainforest, but most parts of the area are savannah-like with tall grasses and scattered trees.

3.4 Topography and Drainage

The drainage system of Ilorin is dendritic in pattern due to its characteristics. The most important river is Asa River which flows in south-northern direction. Asa River occupies a fairly wide valley and goes a long way to divide Ilorin into two parts namely the Eastern and the Western part. The major rivers are Asa, Agba, Alalubosa, Okun, Osere and Aluko. Few of these rivers drain into river Niger or river Asa (Oyegun, 1986; cited in Raimi et al., 2018). The general elevation of land on the western part varies from 273 m to 364 m (i.e., 900 to 1/200 ft) above sea level. To the north of the western part of Ilorin exists an isolated hill known as Sobi hill which is about 394 m high above sea level. The state has River Niger as its natural boundary along its northern and eastern margins and shares a common internal boundary with Niger State in the north, Kogi State in the east, Oyo, Ekiti and Osun States in the south and an international boundary with the Republic of Benin in the west. It is therefore appropriate to say that the state is indeed a middle belt state serving as a “gateway” between the North and the South and in fact a “melting point” for the northern and southern cultures of a relatively flat and undulating land with interine and lacustrine deposits, sparsed hills and valleys in parts of Baruten, Kaiama and Moro local government areas.

3.5 Land Use

The major occupation of the people is mixed farming. The wide expanse of arable and fertile soil and favourable climatic conditions supported the cultivation of variety of food and cash crops, including cashew, yam, beans, groundnut, varieties of vegetables, maize and guinea corn. The rearing of animals is made possible due to the existence of savannah type of vegetation. Other prominent economic activities include cloth weaving, pottery making, blacksmithing, Shea butter production, and gum processing (Raimi et al., 2018).

3.6 Sample Collection

Collections of samples were restricted to air quality. Air quality sources was selected randomly within the vicinity of the study area, but at different distances from each other for the purpose of this study. Also, the collected samples were at different locations. These locations include: Kanisuru Sawmill, Eiyenkorin Sawmill, Oluwaniagbaraemimi Saw mill, OlowoyeAmoyo Sawmill, Odo-okun Sawmill, Irelopeojaoke Sawmill, Irewolede Sawmill, Ibudo Osho Sawmill, Asa dam Sawmill, Akerebiata

Sawmill, Oluwaseun Sawmill etc (See Figure 1 above). The monitoring exercise were taken in the daytime, between 9.00am and 6.00pm. Night samples was not collected. Sampling was carried out between 1st July 2019 through 1st of August 2019 within major sawmill environment in Ilorin Metropolis, each day for a period of one month on an alternate day.

3.7 Equipment Employed

3.7.1 Handheld Gas Detector

Hand held mobile multi-gas monitor with model AS8900 (Carbon Monoxide (CO), Hydrogen Sulphide (H_2S), Combustile (LEL), and Oxygen (O_2)), BLATN with model BR—Smart Series air quality monitor (Particulate Matter (PM_{10}), Formaldehyde) and air quality multimeter with model B SIDE EET100 (Dust ($PM_{2.5}$), VOC, Temperature and Relative Humidity) equipment will be used to detect the presence and precise quantity of the following individual gases, viz: Carbon Monoxide (CO), Particulate Matter ($PM_{2.5}$), Particulate Matter (PM_{10}), Hydrogen Sulphide (H_2S), Volatile Organic Compound (VOC), Combustile (LEL), and Oxygen (O_2).

3.7.2 Global Positioning System (GPS)

Spatial positioning of different sawmill locations was collected through the use of a hand held Global Positioning System. The GPS was helpful in obtaining the selected areas in the community and data obtained was used to produce a digital map through the Arc view GIS software.

3.8 Statistical Analysis

Mean, standard deviation and coefficient of variation were calculated for each of the parameter (Oxygen, VOC, $PM_{2.5,}$ PM_{10}, LEL, formaldehyde, temperature and relative humidity). Pearson correlation was used to determine the correlations between the parameters. Also, the relationship of these parameters and distance was analysed using Pearson correlation. Levels of these parameters relative to their respective FMEV and WHO standards were compared for statistical significance using one sample t-test. Furthermore, data obtained was also analysed using multiple linear regression. Statistical significance was calculated at 0.05 level of significance with $p<0.05$ indicating the statistical significance. All data analysis and computations of result were performed using the Statistical Package for Social Sciences (SPSS version 22.0).

4. Results

Table 1. Correlation between the Variables in the Study Area (Kwara State)

Variables	1	2	3	4	5	6	7	8	9	10
1. Temp (O^0C)	1									
2. RH	0.02	1								
3. VOC (ppm)	-0.28	-0.03	1							
4. CO (ppm)	-0.14	0.06	-0.39**	1						
5. O_2	-0.18	0.07	0.34**	-0.35**	1					
6. $PM_{2.5}$ (ug/m^3)	0.07	-0.08	-0.13	0.38**	-0.18	1				
7. PM_{10} (ug/m^3)	0.05	-0.12	-0.15	0.37**	-0.07	0.99**	1			
8. HcHo (mg/m^3)	0.35*	0.03	0.18	0.08	0.26*	0.44**	0.44**	1		
9. LEL (%)	-0.53*	-0.06	0.17	-0.06	0.23	-0.18	-0.15	0.02	1	
10. Elevation	0.18	-0.16	-0.32**	0.37**	-0.54	0.06	0.06	-0.21	-0.37	1

Note. **significant at 1% ($p<0.01$), *significant at 5% ($p<0.05$).

Table 1 presents the correlation between the parameters. Result shows that the level of temperature in the study area has significant positive relationship with HcHo ($r=0.35$, $p<0.05$) and significantly negatively related to LEL ($r=-0.53$, $p<0.01$). The concentration of VOC was found to be positively significantly related to O_2 ($r=0.34$, $p<0.01$) while for CO ($r=-0.39$, $p<0.01$) and elevation ($r=-0.32$, $p<0.01$), significant negative relationship was obtained. There was a significant positive relationship between $PM_{2.5}$ and CO ($r=0.38$, $p<0.01$), PM_{10} and CO ($r=0.37$, $p<0.01$), elevation and CO ($r=0.37$, $p<0.01$) while between O_2 and CO, a negative but significant relationship was obtained ($r=-0.35$, $p<0.01$). Result reveals that O_2 there is a significant positive relationship with HcHo ($r=0.26$, $p<0.05$) but significant negative relationship with elevation ($r=-0.54$, $p<0.05$). There was a significant positive relationship between PM_{10} and $PM_{2.5}$ ($r=0.99$, $p<0.01$), HcHo and $PM_{2.5}$ ($r=0.44$, $p<0.01$) while positive significant relationship was established between HcHo and PM_{10} ($r=0.44$, $p<0.01$). Elevation shows significant negative relationship with LEL ($r=-0.37$, $p<0.01$).

Table 2. Comparison of Air Quality in the Study Area (Kwara State) with the Recommended Acceptable Standards

Air quality parameters	n	Range	Mean	SD	FMEV	WHO Standards
Temperature	75	21.00-46.40	28.27	7.19	29.5-36.9	-
Relative humidity	75	36.40-53.50	43.46	4.84	4.90-75.9	-
VOC	75	0.00-31.00	4.87	9.06	0.50	0.50
CO	75	0.00-23.00	5.44	7.12	50	50
O_2	75	20.50-21.10	20.86	0.10	20.9	>23.5
$PM_{2.5}$	75	0.37-999.00	91.71	118.81	115	75
PM_{10}	63	0.50-999.00	107.78	125.38	150	100
HcHo	63	0.00-0.10	0.02	0.02	0.1- 3.1	30.0
LEL	66	5.00-15.00	10.61	1.53	5	15.5

Table 2 presents results of the comparison of the air quality parameters in the study area (Kwara State) with that of the recommended standards as provided by the Federal Ministry of Environment (FMEV) and World Health Organisation (WHO). Result shows that temperature and relative humidity in the study area were higher than the lowest acceptable standard but lower than the highest acceptable. The level of VOC and LEL were above the recommended FMEV standards while CO, O_2, $PM_{2.5}$, PM_{10} were below FMEV standards. In relation to WHO standards, result shows that VOC, $PM_{2.5}$, $P.M_{10}$ were above the standard while O_2, HcHo and LEL were below the recommended WHO standards.

Table 3. Comparison of the Air Quality Parameters in the Study Area of Kwara State (Temperature, RH, VOC, CO, O_2 and $PM_{2.5}$)

S/N	Locations	Temperature (O^0C)	RH	VOC (ppm)	CO (ppm)	O_2	$PM_{2.5}$ (ug/m^3)
1	Asadam	23.88±1.25 ^{a}	42.65±5.11^a	15.05±10.08 ^{b}	0.00±0.00 ^{a}	20.90±0.05 ^{a}	54.00±12.08 ^{a}
2	Karisunu	28.29±2.45 ^{b}	40.87±4.24 ^{a}	0.29±0.18 ^{a}	7.71±5.65 ^{b}	20.84±0.05 ^{a}	75.29±15.17 ^{a}
3	IbudoOsho	28.00±1.29 ^{b}	43.54±4.80 ^{a}	0.30±0.23 ^{a}	8.00±7.42 ^{b}	20.87±0.05 ^{a}	204.95±353.58 ^{a}
4	Irewolede	27.67±1.21 ^{b}	41.15±4.65 ^{a}	18.70±10.08 ^{b}	1.17±2.86 ^{a}	20.88±0.08 ^{a}	66.83±12.11 ^{a}

5	Oluwaseun	27.13±1.96 [b]	45.81±4.78 [a]	0.23±0.05 [a]	2.91±8.12 [a]	20.86±0.07 [a]	42.60±29.59 [a]
6	OdoOkun	43.46±2.84 [c]	44.08±5.33 [a]	0.47±1.34 [a]	4.17±6.69 [b]	20.81±0.14 [a]	104.42±91.99 [a]
7	Eyenkorin	22.00±1.26 [a]	44.60±4.28 [a]	0.22±0.08 [a]	13.17±6.46 [c]	20.77±0.10 [a]	93.00±4.73 [a]
8	IrelopeOjaOke	22.00±1.00 [a]	40.23±4.72 [a]	0.20±0.01 [a]	16.00±0.00 [c]	20.73±0.21 [a]	89.67±2.08 [a]
9	Oluwaniagbaraemimi	24.00±1.41 [a]	44.60±4.28 [a]	19.20±9.79 [b]	0.00±0.00 [a]	20.95±0.08 [a]	56.17±15.88 [a]
10	OluwoyeAmoyo	23.83±1.33 [a]	47.03±4.50 [a]	0.21±0.02 [a]	6.33±9.81 [b]	20.88±0.04 [a]	69.33±17.52 [a]
11	AkereBiata	24.33±1.03 [a]	41.12±4.59 [a]	0.40±0.21 [a]	8.83±4.54 [b]	20.88±0.04 [a]	151.67±76.19 [a]

Note. Similar superscript means not significantly different ($p>0.05$), different superscript means significantly different ($p<0.05$).

Result shows that there is no significant difference in relative humidity, $PM_{2.5}$, PM_{10}, O_2 and HcHo between the eleven locations ($p>0.05$). The mean temperature in OdoOkun was significantly higher than that obtained in other locations while between Karisunu, IbudoOsho, Irewolede and Oluwaseun, no significant difference was established in their mean temperature. The level of VOC in Oluwaniagbaraemimi, Asadam and Irewolede were significantly higher than that obtained in other locations ($p<0.05$) while between other location, there were no significant difference in VOC ($p>0.05$). Result also shows that Eyenkorin and IrelopeOjaOke reported significant higher level of CO compared with other locations ($p<0.05$). The level of LEL in Odo-okun was significantly less than that obtained in other locations ($p<0.05$) while elevation in Eyenkorin and IrelopeOjaOke were significantly higher than that of other locations ($p<0.05$).

Table 4. Comparison of the Air Quality Parameters in the Study Area of Kwara State (Temperature, RH, VOC, CO, O_2 and PM_{10})

S/N	Locations	PM_{10} (ug/m^3)	HcHo (mg/m^3)	LEL (%)	Elevation
1	Asadam	66.50±15.55 [a]	0.01±0.01 [a]	11.00±0.00 [b]	325.67±5.64 [a]
2	Karisunu	112.71±55.98 [a]	0.02±0.01 [a]	10.57±0.79 [b]	386.31±9.31 [a]
3	IbudoOsho	228.29±342.21 [a]	0.04±0.04 [a]	10.71±0.76 [b]	317.00±9.59 [a]

4	Irewolede	73.83±18.31 ^{a}	0.05±0.03 ^{a}	11.00±0.00 ^{b}	299.43±7.19 ^{a}
5	Oluwaseun	43.88±28.54 ^{a}	0.03±0.03 ^{a}	12.00±1.85 ^{b}	344.24±10.79 ^{a}
6	OdoOkun	-	--	5.00±0.00 ^{a}	983.60±33.86 ^{b}
7	Eyenkorin	119.33±11.00 ^{a}	0.01±0.00 ^{a}	10.33±0.52±0.52 ^{b}	1153.50±7.87 ^{c}
8	IrelopeOjaOke	108.00±6.93 ^{a}	0.01±0.01 ^{a}	9.67±0.58 ^{b}	1814.67±1217.29 ^{c}
9	Oluwaniagbaraemimi	71.17±24.27 ^{a}	0.03±0.02 ^{a}	11.00±0.00 ^{b}	308.92±8.46 ^{a}
10	OluwoyeAmoyo	87.67±22.11 ^{a}	0.02±0.02 ^{a}	11.00±0.00 ^{b}	378.00±12.78 ^{a}
11	AkereBiata	180.67±89.23 ^{a}	0.03±0.03 ^{a}	10.50±0.55 ^{b}	789.05±381.95

Note. Similar superscript means not significantly different ($p>0.05$), different superscript means significantly different ($p<0.05$).

5. Discussion

5.1 Bivariate Relationship between Air Quality Parameters

The woodworking processing activities and making of furniture at sawmills include the use of many chemicals (adhesives, thinners, paints, preservatives, etc.). These release of chemicals such as VOCs into the ambient air, hence increasing the levels of concentration of photochemical oxidants. Specifically, the Pearson's correlation coefficient for air quality parameter as shown in Table 1 revealed more precisely the nature and strength of bivariate relationship among the sample variables. It seems that there is a remarkable strong positive correlation among PM_{10} concentration and $PM_{2.5}$ (0.99, $p<0.01$) and carbondioxide (CO) (0.37, $p<0.01$) concentrations between oxygen (O_2) concentration and volatile organic compounds (VOC) concentration (0.34, $p<0.01$) among the concentration of $PM_{2.5}$ and carbondioxide (CO) concentration (0.38, $p<0.01$) between the concentration of Formaldehyde (HcHo) and PM_{10} (0.44, $p<0.01$) and $PM_{2.5}$ (0.44, $p<0.01$) concentration between Elevation and carbondioxide concentration (0.37, $p<0.01$) respectively. This outcome is in line with highly remarkable values recorded by Raimi et al. (2018) in their studies on "assessment of air quality indices and its health impacts in Ilorin metropolis, Kwara State, Nigeria". This outcome indicates that as PM_{10} in sawmill environment increases, $PM_{2.5}$ increases significantly, As Formaldehyde (HcHo) increases PM_{10} and $PM_{2.5}$ increases significantly, as Oxygen (O_2) increases volatile organic compound (VOC) increases, as carbondioxide (CO) increases PM_{10} and $PM_{2.5}$ concentration increases. This may be due of reaction of pollutants or planetary boundaries interplay. Similarly, there exists remarkable positive correlation among Formaldehyde (HcHo) concentration and temperature (0.35, $p<0.05$) and oxygen (0.26, $p<0.05$) concentrations. However, there *was a* significantly negative correlation between carbondioxide (CO) concentration and Volatile Organic Compound (VOC) concentration ($p<0.01$) and between oxygen (O_2) concentration and carbondioxide (CO) ($p<0.01$), between combustible (LEL) concentration and temperature ($p<0.05$), and between elevation and volatile organic compound (VOC) ($p<0.01$) concentration. This implies that, as Volatile Organic Compound (VOC) and oxygen concentration increases, carbondioxide (CO) decreases considerably, as temperature increases combustible (LEL) concentration decreases significantly and as VOC concentration increases elevation decreases significantly. This may be attributed to the toxic nature of these pollutants.

5.2 Comparison of Air Quality with the Recommended Acceptable Standards

The most significant part of monitoring inventory of emission is to ensure its validation with the ambient air quality data. Practically, the situation is impossible to accurately appraise emissions from all sources in an area, especially where sources change over time and in space, because emission inventories are constructed on the basis of different assumptions as well as missing data projections. The availability of primary data is every year and it is for these records to reflect the time dynamics as well as space. Statistically, emissions validation using obtained concentrations with acceptable standards and models. However, it must be borne in mind that the formulation of air quality models are themselves based on atmospheric processes assumptions. The best qualitative technique for estimating emissions is to liken their trend through the concentrations observed from a ten-year study such as the current study. Raimi et al. (2018) attempted to validate emissions from industrial site of Temidire Irewolede Community (TIC) for a period of eight weeks at twenty-four (24) locations using data of air quality monitoring sampling stations in Kwara State. In the current study, estimates of emission and concentrations of Carbon monoxide (CO), Particulate Matter ($PM_{2.5}$), Particulate Matter (PM_{10}), Volatile Organic Compound (VOC), Combustible (LEL), Formaldehyde, Oxygen (O_2), temperature (O^0C) and relative humidity (RH) in the study area are compared with same pollutants as the acceptable standards recommended at monitoring station, for the period of two months. The oxygen analysis found in the study area was non remarkable from that of FMEV standard but was well remarkably below that of the WHO standard. This result is consistent with the report by Raimi et al. (2018) which indicates that the level of oxygen found in the study area did not differ remarkably from that of FMEV standard ($p=0.075$, $p>0.05$) but remarkably above that of WHO standard ($p<0.0001$).

However, this current study show oxygen level is above the recorded oxygen level reported by Raimi et al. (2018). The results also showed that the level of combustible (LEL) was significantly lower than that of WHO acceptable value but not significantly different from that of FMEV standard. Such findings confirm the results of qualitative and quantitative analysis results, indicating that VOCs level are twice as high as the FMEV and WHO standard. The elevated VOCs presented in these studies, especially in terms of occupational health of workers in the sawmill is alarming, although consistent with findings of results obtained from previous works (Bean & Butcher, 2006). Elevated concentration levels of VOCs could lead to respiratory problems and may cause distress to asthmatics among industrial workers. This finding agrees with highly significant values reported by Raimi et al. (2018)

based on their studies on assessment of air quality indices and its health impacts in Ilorin metropolis, Kwara State, Nigeria. This can be explained by a wide range of finely divided solids that may be dispersed into air from combustion process and sawmill activities at the sawmill environment, industrial activities or natural sources. The significant difference in the level of urbanization, or the significant difference in physiographic characteristics could also be attributed to saw mill sources as well as planned burns and it could be referenced against known events (Raimi, 2008; Raimi et al., 2018). Likewise, regardless of the homogeneity of outcomes from these sawmill despite its configuration, may have been influenced by the intrinsic deterministic nature. These VOCs react with primary anthropogenic pollutants especially, NOx, SO_2 and anthropogenic organic carbon compounds-to produce haze of secondary pollutants (Janice, 2002; Raimi et al., 2018). The mean concentration of VOC in the air of the sawmill environment is 4.87. This is higher than the mean value of 1.20 reported by Raimi et al. (2018) in their study. This could be attributed to tree filing, soot and smoke from the sawmill environment and therefore poses a problem to the health of the residents and people in the area and also to environmental sustainability. This finding corroborate with highly significant values recorded by Tawari and Abowei (2012) and Raimi et al. (2018) in their studies. The actual health damage caused by dust particles depends upon its nature and composition.

The result also shows that the level of combustible (LEL) was significantly less than that of WHO acceptable value but not significantly different from that of FMEV standard. Similar studies support the qualitative and quantitative analysis results, indicating the level of VOC was significantly above that of FMEV standard and that of WHO standard. The elevated VOCs as shown in this results especially in terms of occupational health of workers in the sawmill is worrisome, although consistent with results obtained from previous works (Bean & Butcher, 2006). Elevated concentration levels of VOCs could lead to respiratory problems and may cause distress to asthmatics among workers in the industry. This finding agrees with highly significant values recorded by Raimi et al. (2018) in their studies on assessment of air quality indices and its health impacts in Ilorin metropolis, Kwara State, Nigeria. This can be explained by a wide range of finely divided solids that may be dispersed into air from combustion process and sawmill activities at the sawmill environment, industrial activities or natural sources.The significant difference in the level of urbanization, or the significant difference in physiographic characteristics could also be attributed to saw mill sources as well as planned burns and it could be referenced against known events (Raimi, 2008; Raimi et al., 2018). Moreover, the homogeneity of outcomes from these sawmill despite its configuration, may have been influenced by the intrinsic deterministic nature. These VOCs react with primary anthropogenic pollutants specifically, NOx, SO_2 and anthropogenic organic carbon compounds-to produce haze of secondary pollutants (Janice, 2002; Raimi et al., 2018). The mean concentration of VOC in the air of the sawmill environment is 4.87. This is higher than the mean value of 1.20 given by Raimi et al. (2018) in their study. This could be attributed to tree filling, soot and smoke from the sawmill environment and therefore poses a problem to the health of the residents and people in the area and also to environmental sustainability. This finding corroborate with highly significant values recorded by Tawari and Abowei (2012) and Raimi et al. (2018) in their studies. The actual health damage caused by dust particles depends upon its nature and composition.

According to the Indian Health Care Institute, the number of patients with respiratory problems in Delhi hospitals is alarming (Indian Express, 1996). In addition, the mean concentrations of $PM_{2.5}$ and PM_{10} in the studied samples were 91.71 and 107.78 respectively. This is worth more than the mean value of 64.58 and 43.22 given by Raimi et al. (2018) in their study. This situation is expected to have adverse implications on the health performance of employees in the sawmill. Prolonged exposure to high concentration levels of PM_{10} may cause throat and lung irritation, bronchitis and possibly premature death (Karr et al., 2007). However, the results of this study contradict the above findings and $PM_{2.5}$ and PM_{10} were both significantly lower than FMEV standards and respectively higher than WHO standards, thus the air has met the "low health category" considering the FMEV standards and posing no threat to the health and environment. This means that the levels of $PM_{2.5}$ and PM_{10} particles in the air can be considered healthy for the resident of the sawmill communities and everyone. However, Both $PM_{2.5}$ and PM_{10} are respectively higher than WHO standards, thus could results in a call to public health action and should be given utmost attention because the present concentration could be due to anthropogenic activities of the sawmill industry present in the study area. Similarly, according to Benjamin D. Horne "Long-term chronically elevated levels of ambient fine particulate matter ($PM_{2.5}$) air pollution such as those seen in major population centers across the globe are associated with the development of chronic respiratory, cardiovascular and other diseases, as well as death due to these conditions. Chronically high $PM_{2.5}$ pollutions is also linked to death due to Acute Lower Respiratory Infections (ALRI), including pneumonia and influenza. In geographic regions where $PM_{2.5}$ pollution levels are, on average, relatively low but where large short-term acute increases can occur, a dose-response relationship has been observed between acute $PM_{2.5}$ elevation and regional epidemics of ALRI manifesting as bronchiolitis, influenza and pneumonia in children and adults". The concentration of $PM_{2.5}$ and PM_{10} measured seem highly significant and cumulative effect might be harmful to health. Interestingly, the sources of particulate matter can be manmade or natural. Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation and sea spray. Human activities, such as the burning of fossil fuels in vehicles, power plantsand various industrial processes alsogenerate significant amounts of aerosols. Averaged over the globe, anthropogenic aerosolsthose made by human activitiescurrently account for about 10% of the total amount of aerosols in our atmosphere. Elevatedlevels of fine particles in the air are linked to health hazards such as heart disease (Molles, 2005; Raimi et al., 2018) altered lung function and lung cancer. Persistent free radicals connected to airborne fine particles could cause cardiopulmonary disease (Bronwen, 1999; Raimi et al., 2018). Although, the measured concentrations of CO in air around the saw mills investigated were below the instrument detection limit. Carbon monoxide in air is the product of incomplete combustion, which is primarily released from the emissions of vehicles and generators.

Although, it sources is not solely from the exhaust of the operating power generating set, since air current may contain intractable concentration from diffuse sources. Carbon monoxide values were expected to be high due to high traffic flow and continuous releases of vehicular emissions in around most of the saw mills. Although the measured concentration levels of CO were well below the set FMENV ambient air limits of 10 ppm, atmospheric CO is of concern because of its obvious human health and climatic effects. This is because most of the saw mills are located within residential and commercial areas. Carbon monoxide inhalation causes muscular reflexes, impairs thinking and causes drowsiness by reducing the oxygen carrying capacity of the blood. It is also associated with increase in the likelihood of exercise related pain in people with coronary heart disease. CO is a known neurotoxin, and there is a potential for chronic exposure to exert neurologic effects. Furthermore, it has been associated with effects on prenatal and early postnatal mortality and low growth in children of women exposed during pregnancy. These effects are presumably due to oxygen deprivation.

5.3 Comparison of the Air Quality Parameters

In spite of variances in time and location, there are limited statistically remarkable differences in temperature levels of (OdoOkun), VOCs (Oluwaniagbaraemimi, Asadam, Irewolede), CO (Eyenkorin, Irelopeojaoke) and elevation (Eyenkonrin, Irelopeojaoke), etc. Geographic analyses suggest systematic differences in exposure by community. For instance, VOC levels are higher in Oluwaniagbaraemimi, Asadam, Irewolede area were significantly higher than that obtained in other locations ($p<0.05$). This concentration in this study was higher than the value reported by Raimi et al. (2018) for Temidere Irewolede Community (TIC) (1.20μg/m^3). In Ilorin Metropolis, Kwara State, Nigeria. The finding of the present study is indicating that, there is a spatial variation of VOC concentration over the selected study sites and CO results obtained from the present study revealed that there is a spatial (site to site) variation of CO concentration even though the overall concentration trend of CO concentration in Eyenkorin and Irelopeojaoke reported significant higher level of CO compared with other saw mills locations ($p<0.05$), this sawmill happened to be one of the very busiest route and business center and state cross bus station and could be due to the indirectly increased vehicle congestion around Eyenkorin and Irelopeojaoke. The high values of CO obtained around Eyenkorin and Irelopeojaoke sawmill were not surprising considering the volume of fossil fuels consumed on daily basis to power different equipment, added to the disposal of sawdust and other wood wastes by open incineration. These activities emit many gaseous pollutants including CO that may cause irritation of respiratory tracts and lungs, adversely affect workers defence system against pathogens and elevate the risk of respiratory tract infections (Akunne et al., 2006). Many researchers also reported that air pollution due to wood burning was positively associated with hospital emergency visits for pneumonia (Ozdilek, 2006; Peel et al., 2005). A mechanistic theory consistent with the findings of this study holds that the development of respiratory symptoms, preterm births, increased use of asthma medication and reduced lung function (Hertz-Picciotto et al., 2007; Ritz et al., 2007; Molitor et al., 2007; Jarrett et al., 2005) may be associated with the high value obtained on PSI (pollutant standard index) which described the ambient air quality at Eyenkorin and Irelopeojaoke sawmill as unhealthful. Models of exposure based on both activity patterns and ambient monitoring show that low-income and vulnerable groupsincluding children are exposed to the highest levels of VOCs, CO and particulates in Oluwaniagbaraemimi, Asadam, Irewolede, Eyenkorin, Irelopeojaoke. Also higher temperature was experience in Odookun saw mill and was significantly higher than that obtained in other locations. Although, temperature has been rising on average, in the world and can be used as a surrogate for the meteorological factors influencing surface ozone formation (Camalier et al., 2007). Our results suggest a trend of increasing temperatures and these rising temperatures have the potential to cause thousands of deaths and cost billions of naira. Temperature and humidity have been well known to be predictors of death and are an important factor in the analyses and this temperature change is greater than that seen in other saw mills. This variant suggests a long-term adaptation to the local climate, and underlines the importance of careful site-specific adjustment for temperature while assessing the effects of other environmental concerns such as air pollution. Similarly, higher elevation was reported at Eyenkorin, Irewolopeojaoke and were significantly higher than that of other locations ($p<0.05$). The level of LEL in Odo-Okun was remarkably less than that obtained in other locations ($p<0.05$).

6. Conclusion

The eye smarting at sawmill is annoying even if it has not been shown that it is likely to damaged health. Certainly, air pollution naturally disrupts the ordinary business and pleasure of life, given reasons enough for the vigour of the complaints and at the present time, there is a vital question around air quality that people inhale individually in sawmills and several snags that its pollution would cause on the public health (respiratory, pulmonary and cardiovascular diseases, increase of infections) and on the environment (destruction of the ozone layer, global warming, climatic catastrophes). It can be concluded that the average concentrations of CO, O_2 and other measured parameters such as Formaldehyde (HcHo) etc are generally lower and within tolerable range of National and International regulatory standards for air quality indices. However, there are some exceptions such as the average concentrations of volatile organic compounds (VOCs), $PM_{2.5}$, PM_{10} and Combustible (LEL) respectively high compared to National and International standards. This high value is associated with the amount of pollutant present in the sawmill air due to influents of input from the activities of sawmill. Hence, Ilorin metropolis air pollution were however found to be polluted. As a result, it is concluded that far-reaching efforts must be made to reduce air pollution levels around the sawmill environment. Decreasing air pollution saves and advances quality of lives. It can help reduce the risk of acute and chronic respiratory infections such as pneumonia and asthma between vulnerable and sensitive groups including children. Reducing air pollution will reduce complications during pregnancy and childbirth for the resident of the sawmill communities, as well as advance development of the community, aiding them to live longer and more productive lives, as well as benefit sustainable development and climate change mitigation. The dearth of accurate information on the diverse sources of pollution, the pollution state and degree at sawmills, by the government or municipal authorities and policymakers could lead to sort of commitments to limit air pollution in the country and made the occurrence of pollution from persisting.

7. Recommendations

By and large, this study can serve as an important tool to support pollutants in monitoring concentration, i.e., environmental pollution. However, characteristics that affect individual health, neighbourhood, community, or even national level. Subsequently, research methods, as well as intervention strategies, differ across the spectrum from individual to national levels of organization. To advance on the current air quality monitoring and assessment programmes in sawmill environment, Recommendations were advanced with respect of the several levels of interaction to embark on the following:

i. Improving saw mill monitoring and modelling of air quality: Levels of pollutant can both vary horizontally and vertically, especially in saw mill settings. Combined with the requirement to enhanced characterize concentrations of pollutant and exposures in saw mill environments, access to these facts should be available to communities, researchers, and decision makers. Just as important as the types of statistics collected are the target locations for monitoring pollution at saw mill. Up-to-date monitoring sites are not constantly located to make known saw mill inequities. For most part there is inadequate spatial and time-based feature to answer exposure associated questions in saw mill environments. Current monitoring sites may or may not contain hot spots and represent the entire exposed area. Distribution modelling can be used to recognize where these monitors may best be located, but a large number of monitors is needed to guarantee that high concentration areas are found. Currently hot spots are determine by air quality data alone. Air pollution siting and monitors should include site selection in terms of health hot spots and proximity to facilities and intersections of concern that may increase exposures. Expansion and improved existing target of air-monitoring systems will require concerted effort of local, state, and federal agencies and participation in educational and community interests.

ii. **Exposure target assessment**: Detail all-inclusive report of actual urban populations exposures will significantly increase the ability to characterize the risks of ambient concentrations. For example, the usage and development of further unreceptive dosimeters will make available a non-invasive monitoring means of VOC and further HAP exposures that is equally easy and practical. Because of its ease of usage, monitors that are passive are an outstanding instrument for direct engagement of communities in monitoring the ambient concentrations and individual exposures. In addition, through an improved description of saw mill exposures, more research are needed into the subsequent mechanisms of assessment exposure in saw mill settings: Time-activity outlines in specific community settings, microscale disparities in ambient concentrations of HAPs focus on local sources, lessons are required through vertical and horizontal gradients in focus over insignificant spatial scales, improved air quality emissions standards, including both emissions factors and geographic information, or procedures to identify specifying locations in the context of small distribution sources, procedures and models for efficient use of data sets for community-based source inventory which must be established.

iii. **Interdisciplinary adoption of method to data collection and analysis**: Current data sources from other section can be used to learn more about health differences among saw mill inhabitants. There are important sources of valuable information for secondary usage which remain available from the administrative registration systems, including key information events registries, hospital admissions, which can also contribute to our understanding of inequities in urban health. An interdisciplinary method is needed to analyses available data. Health services should play a more significant role in analyzing and using air quality data, and annual air quality reports should be obtained at public meetings organized by appropriate health and environmental agencies. Community environmental health advisory committee should be set up, trained and educated to communicate and to monitor this ongoing effort with communities particularly resident of saw mill. Air pollution data can be collected in a much more informative way through an interdisciplinary approach. One example is by intensifying the usage of geographic information systems technology to construct aerial monitoring databases. Information on air pollutant levels and traffic patterns can be covered by data on other risk factors such as specific pollution sources, crowding, and poverty. Current nature of pollution models can be broadened with a biopsychosocial model (characterizes the nested, interactive ecology of biology, mental function, and social status and relations in a range of human pathologies) by incorporating elements derived from the various administrative data tools available from government agencies, using the latest tools available to the public and community ecology. These information range from demographic data to housing inspection information, and other emergency services.

iv. Promote alertness of the harm pollutants cause communities and residents of the sawmill on vulnerable and sensitive groups like children, pregnant women and the elderly.

v. Develop monitoring enforcement measures, tools and regulations.

vi. Institute policies planning to reduce pollution that can be caused by future development. Agencies of government such as the Kwara State Ministry of Environment should work in partnership with other development partners, i.e., multinationals and stakeholders in management of air pollution to come up with an all-inclusive Air Quality Management (AQM) outline for the state.

vii. Health warning must keenly be disseminated by state and local government to the resident of the sawmill and its surrounding communities so that they can better enhanced and protect themselves from air pollution.

Competing Interests

We declare that we have no conflict of interest that could be perceived as prejudicing the impartiality of the research reported. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Consent

All authors declare that 'written informed consent was obtained from the participants.

Ethical Approval

Ethical approval for the study was sought and gotten from the Institutional Review Board of the Kwara State University. Permission to carry out the research as well as written consent was also obtained from all the sawmills owners and operators after explaining the purpose of the study to them.

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