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Impact of Sawmill Activities on Ambient Air Quality of Udu Area of Delta State, Nigeria

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ABSTRACT

This study was set out to assess the impact of sawmill activities on ambient air quality in Udu Area of Delta State, Nigeria. The findings was achieved by monitoring and quantification of Nitrogen oxides (NO_X), Volatile Organic Compounds (VOC), Sulphur Oxides (SO_X), Carbon monoxide (CO), Suspended Particulate Matter (PM), Wind Speed and Wind Direction in and around settlements close to the Udu river during wet and dry season. The air quality status of the sampled areas was analyzed using Aero Qual series 500, MetOne Inst. (Aerocet 531S). Concentrations of pollutants analyzed were in the ranges for wet season; $PM_{2.5}$ (15.80-74.0 μg/m^3), PM_{10} (37.90-103.4μg/m^3). Other results in (ppm) CO (0.01-0.47), CO_2 (322-435.40). Dry season; (20.08-92.6 μg/m^3) for $PM_{2.5}$, PM_{10} (43.96-133.08μg/m^3). Other results in (ppm) CO (0.01-0.78), CO_2 (353-559.40). The air quality Index (AQI) ratings of the obtained results showed rating from Good to unhealthy for wet season and Good, moderate and unhealthy for dry season. "There is a need for routine monitoring of the air quality in the study area to ensure good air quality for the residents"

Keywords: Air quality, Pollutant, Sawmill, Sawdust.

INTRODUCTION

Wood processing industries are facilities such as sawmills, plywood mills, pulp and paper plants. The industry is an important part of our daily lives, producing beautiful wooding finish for our homes and offices to make us comfortable. In Nigeria, majority of the sawmill industries are located at the wood producing rain forest areas especially at the southern part of the country. Thus, the largest concentration of sawmills can be found in Lagos, Ekiti, Osun, Cross River, Ondo, Oyo, Imo, Edo, Delta and Ogun States (Bello and Mijinyawa, 2010). This accounts for over 90 % of the sawmilling activities in the country (Alagbada et al., 2021).

As rightly opined by Ajibefun and Daramola (2004), sawmilling industry, among other micro-enterprises is in the forefront of promoting the economic growth of the country. The industry employs a significant proportion of the rural population in technical jobs such as: power saw operators, saw doctors and mechanics, as well as in distribution, and wholesale of the wood products (Alvar, 1983). In terms of performance, Aruofor (2003) revealed that Nigerian sawmills capacity is estimated at 11,684,000m^3 per annum in log equivalent while capacity utilization was put at 5,422,000.m^3 per annum.

The siting and operations of sawmills impact negatively on the environment in several ways which include but not limited to pollution of water bodies, destruction of breeding grounds for fishes and other aquatic organisms such as mudskippers, snakes, crabs, and other reptiles, destruction of mangrove, raffia palm, and various species of trees, grasses and sedges, and general degradation of the riparian environment which is a key driver of global warming (Adhikari & Ozarska, 2018).

Over the years, much exploitation of the forest resources has been done in order to meet the increasing demand of the teeming population. This has resulted in serious depletion of the resource base to the extent that some favored timber species have become scarce while others have become extinct in certain ecological zones. More recently however, there have been changes in the structure of the forestry sector. The forest resource survey, 1996-1998, revealed that the forest cover has decreased by 20% over the preceding 18 years. According to Adeyoju (2001), the total forest estate which stood at 10% of the country's land area in 1996 is now less than 6%. Ola Adams and Iyamabo (1977) estimated that about 26,000 ha of forest land are destroyed annually in the rainforest zone during the conversion of natural forests to plantation forests and other forms of land use. World Wildlife Fund estimated that over 90% of the natural vegetation had been cleared and over 350,000 ha of forest and natural vegetations are lost annually (Okafor et al., 1996), these occurrences have significant impact on the operations of the forest industries leading to a decline in the contribution of the industries to national industrial development. In a study by Geetha *et al*, (2015) to determine the environmental performance from gate-to-gate in the sawmilling industry using the life cycle assessment technique. Data pertaining to the saw-logs and energy consumption were obtained and calculated, and the environmental performance assessed. The study focused on two different size sawmills and two tropical hardwood species. The findings concluded that several types of gases namely, CO_2, CH_4, NOx, N_2O, SO_2, and CO were discharged to the environment as a result of sawmilling processes. The discharge of these gases impacted the environment in the form of global warming, acidification, human toxicity, eutrophication, and photo-oxidant formation potentials (Geetha *et al*., 2015).

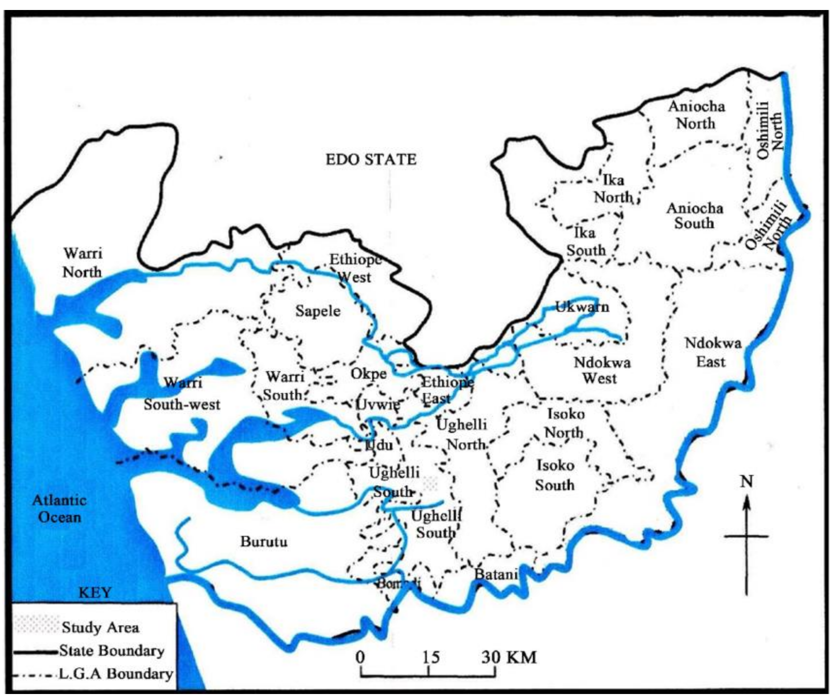
A study carried out by Raim *et al* (2020) assessed ambient air quality in major sawmill sites in Ilorin Metropolis, Kwara State, Nigeria. The results revealed that the mean concentrations of CO, O_2 and other measured parameters such as Formaldehyde are commonly lower and within acceptable range of 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.

Oguntoke *et al*. (2019) noted that indiscriminate disposal and open burning of sawmill and municipal solid wastes constitute hazards to the quality of the immediate environment and human health. This study assessed the levels of pollutants emitted by burning sawmill and municipal wastes, and their potential hazards. Nine selected sawmills and 6 municipal solid-waste dumps in Abeokuta metropolis were investigated. During waste burning, the concentrations of NO_2, SO_2, CO, H_2S, NH_3 and VOC were monitored in replicates at the dumpsites, 10 m, 20 m and the nearest houses using portable samplers (Aeroqual and Multi-RAE). The mean concentrations of NO_2, SO_2 and VOC were below permissible limits at most locations while CO values were higher at all dumpsite. Raimi *et al*. (2020) stated in their study that 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. Ayodele & Adedayo (2024) in their findings established that fine particulate matters of 0.3μm and 0.5μm were the major particles affecting the ambient air quality posing high health challenges. The objectives of this paper is to measure and analyze some gas pollutants in the study area and to determine the Air quality index.

MATERIALS AND METHOD

Study Area

Delta State is one of the States in the South-South geopolitical zone of Nigeria. It is a state under Niger Delta, an oil rich region. Delta State was formed from the former Bendel State in August 27, 1991. Bordered on the north by Edo State, the east by Anambra and Rivers States, and that south by Bayelsa State while to the west is the Bight of Benin which covers about 160 kilometers of the State's coastline. Udu is a town in the Udu Clan, under Udu Local Government Area of Delta State, Nigeria. Its population is over 32,000. Udu shares boundaries with Aladja, Ekete, Owhase, Egini, Orhuwhorun and Ujevwu communities.



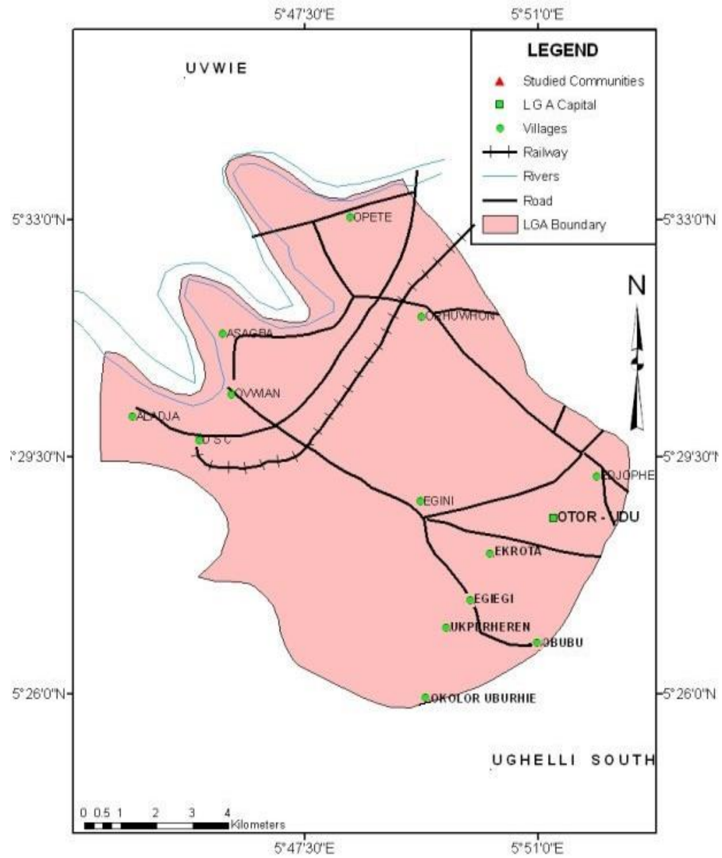


Figure 1: Administrative Map of Delta and Udu LGA showing the sampling location

Data Collection

Collection of Air Samples:

Air samples were measured in-situ at a Sawmill near the Udu river, under Udu Local Government Area of Delta State. Five (5) sampling points were established within the sawmill area, while two (2) control sample were collected outside the study area. The air samples were collected in the Morning, Afternoon and Evening, to assess the impacts with regards to time. Also, the sampling was carried out during the dry and wet seasons. All the sampling points were geo-referenced using Global Positioning System (GPS) to establish the sampling coordinates.

Table 1: Geographical Coordinates of the Sampling Points

Parameters	Geographical Coordinates		Description
	Longitude (N)	Latitude (E)	
Station 1	05.51506	005.78443	1st point of wood cutting machine
Station 2	05.51513	005.78452	4th point of wood cutting machine
Station 3	05.51517	005.78484	Along the road of the sawmill
Station 4	05.51525	005.78590	7th point of wood cutting machine
Station 5	05.51102	005.78469	Entrance to sawmill
Control Station 1	05.51016	005.78429	After bridge, from Udu junction
Control Station 2	05.52495	005.78351	Before bridge, from Udu junction

Equipment

Air pollution measurements were made using direct reading through automatic in situ gas monitors. They are:

- AeroQual series 500 (with different gaseous air pollutant census)
- MetOne Inst. (Aerocet 531S), for Particulate Matter (PM) detection
- Sper Scientific Weather Meter, for Wind Direction
- Davis Instrument Turbo Wind Meter Indicator, for wind speed
- Integrated Sound Level Meter, for noise measurement

METHODOLOGY

Suspended Particulate Matter ($PM_{2.5}$, PM_{10} and TSP)

The SPM measurement was carried out using MetOne Instrument (AEROCET 531S). The instrument is a real time dust monitor designed for air monitoring investigations. It uses infrared technology to obtain accurate and instantaneous data on airborne particle concentrations, in accordance with the NIOSH method 0600. It is of 9”x3”x1.5” dimension weighing about 0.75 kg with concentration range of 0.01-200 mg/m^3 and can capture PM10 and TSP levels. It displays 4/20 alphanumeric on-screen display LCD 3.5 digits mg/m^3 concentration reading which allows for a complete time vs. concentration profile. It is with a recording time of 1 min to 12 hours, a sampling rate of 1 or 2 sec/sample with facility for TWA, STEL, MAX/MIN concentration, and start/stop time. The monitor was placed at a distance of at least 1 m above the ground level to measure SPM at selected locations.

NO_X Measurement

The NO_X concentration of interest measured was Nitrogen dioxide (NO_2) using an *in situ* single gas NO_X monitor (aeroQUAL meter series 500) with sensor number 2711133-002. The monitor is a 9.3 cm x 4.9 cm x 2.2 cm measuring instrument weighing about 0.1 kg with an instantaneous direct readout displays through which current NO_2 concentrations can be continuously monitored in ppm (parts per million) with a detection range of 0 – 20 ppm and 0.1 ppm resolution. It has facility for Short Term Exposure Limit (STEL) from which the NO_2 concentration for the last 15 minutes can be determined; the Time Weighted Average (TWA) from which the accumulated reading of the gas concentration since the monitor was turned on is divided by 8 hours; and the Peak Reading, which is the highest reading since the monitor is turned on.

SO_2 Measurement

An *in situ* single gas SO_2 monitor (aeroQUAL meter series 500) with sensor number 1109132-004to measure the concentration of Sulphur dioxide. The monitor is a 9.3 cm x 4.9 cm x 2.2 cm measuring instrument weighing about 0.1 kg with an instantaneous direct readout displays through which current SO_2 concentrations can be continuously monitored in ppm (parts per million) with a detection range of 0 – 20 ppm and 0.1 ppm resolution. It has facility for Short Term Exposure Limit (STEL) from which the SO_2 concentration for the last 15 minutes can be determined; the Time Weighted Average (TWA) from which the accumulated reading of the gas concentration since the monitor was turned on is divided by 8 hours; and the Peak Reading, which is the highest reading since the monitor was turned on.

CO and CO_2 Measurements

The measurements were taken using an *in situ* non-integrated single gas carbon monoxide monitor (aeroQUAL meter series 500) with sensor number 2907132-004. The monitor is a 9.3 cm x 4.9 cm x 2.2 cm measuring instrument weighing about 0.1 kg with an instantaneous direct readout displays through which current carbon monoxide concentrations can be continuously monitored in ppm (parts per million). It has facility for Short Term Exposure Limit (STEL) from which the carbon monoxide concentration for the last 15 minutes can be determined; the Time Weighted Average (TWA) from which the accumulated reading of the gas concentration since the monitor was turned on is divided by 8 hours; and the Peak Reading, which is the highest reading since the monitor is turned on. It has detection range of 0 – 500 ppm with 1 ppm resolution.

VOCs and H_2S Measurements

VOCs and H_2S measurements were taken using an *in situ* (aeroQUAL meter series 500) with sensor number 2803131-010 and 0111131-002 respectively. The monitor is a 11.8 cm x 7.6 cm x 4.8 cm measuring instrument weighing about 0.454 kg with an instantaneous direct readout displays through which current VOCs and H_2S concentrations can be continuously monitored in ppm (parts per million and microgram per gram). It has facility for Short Term Exposure Limit (STEL) from which the carbon monoxide concentration for the last 15 minutes can be determined; the Time Weighted Average (TWA) from which the accumulated reading of the gas concentration since the monitor was turned on is divided by 8 hours; and the Peak Reading, which is the highest reading since the monitor is turned on. It has detection range of 0 – 100 ppm with 1 ppm resolution for H_2S and 0 – 200 ppm with a resolution of 0.1 ppm for VOCs.

Handheld Meteorological Meter

Hand held mobile meteorological meters was used to measure wind speed and wind direction.

RESULTS AND DISCUSSION

Table 4: Concentration of pollutants (Wet Season)

Parameters	Morning		Afternoon		Evening		AVERAGE	
	Study	control	Study	Control	Study	Control	Sawmill	Control
NOx (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SOx (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CO (ppm)	<0.01	0.31	0.47	0.13	<0.01	<0.01	0.47	0.22
CO_2 (ppm)	435.40	394.00	384.00	322.00	406.40	430.50	408.60	382.17
VOC (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
$PM_{2.5}$ (μg/m^3)	15.80	49.85	74.00	31.40	36.20	21.90	42.00	34.38
PM_{10} (μg/m^3)	37.90	78.40	103.40	51.30	55.70	34.60	65.67	54.77
TSP (μg/m^3)	82.36	167.30	223.88	123.50	139.58	89.25	148.61	126.68
Noise Level (dB)	51.06	66.00	79.46	55.50	43.54	56.40	58.02	59.30
Wind Speed	5.18	4.60	4.38	4	4.44	4.05	4.67	4.22
Wind Direction	NE	NE	NE	NE	NE	NE	NE	NE

Table 5: Concentration of pollutants (Dry Season)

Parameters	Morning		Afternoon		Evening		AVERAGE	
	Study	control	Study	Control	Study	control	Sawmill	Control

NOx (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SOx (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CO (ppm)	<0.01	0.54	0.78	0.12	<0.01	<0.01	0.78	0.33
CO_2 (ppm)	559.40	495.50	472.80	353.00	474.60	456.00	502.27	434.83
VOC (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
$PM_{2.5}$ (µg/m^3)	20.08	63.55	92.06	38.15	52.38	33.65	54.84	45.12
PM_{10} (µg/m^3)	43.96	95.50	133.08	61.40	83.24	49.70	86.76	68.87
TSP (µg/m^3)	94.98	193.70	291.00	163.45	185.38	127.95	190.45	161.70
Noise Level (dB)	62.44	78.50	95.12	68.10	51.58	70.75	69.71	72.45
Wind Speed	2.30	1.95	1.16	1.25	2.36	1.50	1.94	1.57
Wind Direction	NE	NE	NE	NE	NE	NE	NE	NE

Table 4 and Table 5 shows variation of gas pollutants measured during different season. For wet season, values for the mean concentrations of carbon monoxide (CO) gave values ranging from 0.01- 0.47 ppm CO_2 (322-435.40). Average value for CO obtained is less than the permissible limit of (10) ppm for CO, while CO_2 showed elevated value above USEPA (2007) threshold of 500pm. The particulate matter for the air quality assessment gave mean concentrations of 15.80-74.0 µg/m^3 for $PM_{2.5}$ and 37.90-103.4µg/m^3 for PM_{10}. The obtained results when compared with USEPA (2017) limits, of 25.00 µg/m^3 and 50.00 µg/m^3 for $PM_{2.5}$ and PM_{10} respectively, is above the average annual set standards. Similar result is seen for during the dry season (Table 5). However, values were far higher that results obtained during wet season. Comparing the results obtained in this study with the previous findings, it was observed that, the values were in line with the earlier findings by Nicholas and Ukoha (2023) who reported higher values of particulate matter, $PM_{2.5}$ (113.00±7.00-133.00±36.07 µg/m3) and PM_{10} (153.30±9.07 - 179.67±48.01 µg/m3). Also, Okudo et al. who also reported higher values of particulate matter; $PM_{2.5}$ (23.06±1.53 - 153.23±28.73 µg/m^3) and PM_{10} (37.49±3.75) in CO, CO_2, $PM_{2.5}$ and PM_{10} their research.

Table 6: Statistical comparison of the two seasons at p value 0.05

Pollutant	**p-value**
CO_2	0.000
$PM_{2.5}$	<0.001
PM_{10}	<0.001
CO	<0.001

The p value for CO, CO_2, $PM_{2.5}$ and PM_{10} are less than 0.05 (Table 6). This implies that there is significant difference for each pollutant collected during the two seasons. Meteorological variables such as wind and precipitation may have contributed to the disparity of air pollutant concentrations (Yavus, 2024).

Air Quality Index

The index was estimated using the equation

$$I_p = \frac{I_{Hi} - I_{LO}}{BP_{HI} - BP_{LO}} (C_P - BP_{LO}) + I_{LO} \quad Equation\ 1$$

Where Ip = the index for pollutant Cp = the rounded concentration of pollutant, BP_{Hi} = the breakpoint that is greater than or equal to Cp, BP_{LO} = the breakpoint that is less than or equal to Cp, BPHi = the breakpoint that is greater than or equal to Cp, I_{Hi} = the AQI value corresponding to BP_{Hi}, I_{Lo} = the AQI value corresponding to BPLo

Table 7: Air Quality Index

Pollutant	$PM_{2.5}$	PM_{10}	CO
Wet season	Unhealthy	Unhealthy	Good
Dry season	Unhealthy	Moderate	Good

Quality Index (AQI) ratings, it was observed that $PM_{2.5}$ and PM_{10} are rated unhealthy for both seasons while CO pose no threat (Table 7).

CONCLUSION

The study clearly showed that sawmill activities have negative impacts on the environment. Also, seasonal variations revealed the air quality assessment tends to be more polluted during the dry season than wet season. The low pollution observed during the wet season might be as a result of low work activities during the season. However, it is possible some meteorological variables may influence the concentrations of pollutant.

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