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THE CONTRIBUTION OF ATMOSPHERIC POLLUTION TO CLIMATE CHANGE IN KADUNA METROPOLIS, NIGERIA

Moses SIMON[1], Handan E. UMARU[2], Alice LIVINUS[3]
[1&2]Department of Environmental Management Kaduna State University
[3]Department of Agricultural Extension and Rural development Kaduna State University

Correspondence email: mosessimon913@gmail.com

ABSTRACT

Purpose: *This study assessed the contribution of air pollution and the effects of selected atmospheric pollutants on climate conditions in Kaduna metropolis. Specifically, it examined the types of air pollution present, the concentration levels of selected gaseous pollutants, and their implications for the local climate.*

Design/methodology/approach: *The study adopted an experimental research design involving fieldwork and direct observation. Air quality measurements were conducted using an MSA Altair 5X gas detector, rented from the Kaduna Environmental Protection Authority (KEPA). Data were collected across four sampling locations—Command Junction, Refinery Junction, Sabo Market, and Leventis Roundabout—representing major traffic and urban activity zones. The data were analyzed using mean values and presented in tables and charts.*

Findings: *The results revealed Particulate matter ($PM_{2.5}$ and PM_{10}) concentrations at all sampling points were within the Federal Ministry of Environment (FMEnv) and NESREA daily permissible limit of 100 ppm, indicating minimal immediate health risk at the time of measurement. However, nitrogen dioxide (NO_2) concentrations recorded at the four sampling points—0.093 ppm, 0.202 ppm, 0.059 ppm, and 0.086 ppm—exceeded the FMEnv and NESREA recommended limit of 0.008 ppm. This suggests significant anthropogenic influence, mainly from vehicular emissions, with potential adverse environmental and climatic effects.* 2

Research limitations/implications: *The study was limited to four sampling points and focused on selected pollutants over a short monitoring period, which may not fully capture seasonal variations. Despite these limitations, the findings provide valuable baseline data for air quality assessment and climate-related studies in Kaduna metropolis.*

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[1] Email: kesj@kasu.edu.ng

Practical implications: *The study highlights the need for continuous air quality monitoring, stricter enforcement of emission control policies, and the establishment of dedicated environmental monitoring teams to mitigate pollution and protect public health and the environment.*

Originality/value: *This study contributes empirical evidence on spatial air pollution patterns in Kaduna metropolis using direct field measurements, offering location-specific data that can inform environmental policy, urban planning, and sustainable development strategies.*

Keywords: Air pollution; Climate effects; Gaseous pollutants; Vehicular emissions; Environmental sustainability.

1.0 INTRODUCTION

Air pollution is defined as the contamination of the atmosphere by noxious gases and particulates pollutants, on the other hand a pollutant is a foreign substance that makes something dirty or impure, especially waste from human activities (Advance learners Dictionary international students edition 8th edition). Similarly, air pollution can be refer as the presence of pollutants such as Sulphur Oxide (SO) particle substances (pm), Nitrogen Oxide (NO) and Ozone (O_3) in the air that we inhale at some levels which create some negative effects on the environment and human health.Therefore, air pollution is a term that is apply to any chemical, physical or biologic agent that affects the natural characteristics of the atmosphere. The atmosphere is a dynamic natural gas system that supports all life on earth. The temperature of the atmosphere has increased of recent because of human activities which gives rise to global warming. Global warming refers to an average increase in the earth surface temperature due to release of greenhouse gases from industrial activities, deforestation and depletion of the Ozone layer (Umeh, 2010).

According to a lecture notes on environmental hazards defined climate change as a statistical distribution of weather patterns lasting for decades or longer (Aboi, 2019). Furthermore, climate change is the increasing in concentrations of Carbon dioxide (CO_2) and other greenhouse gases, Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Nitrogen oxide (NO), Methane (CH^2), Ozone (O3) and water vapour in the earth's atmosphere. The United Kingdom (UK) Cambridge Royal society of chemistry on Nitrogen dioxide (NO_2) concentration showing graph of output from such measurement of annual mean microgram per cubic metre, also has around 300 air quality monitoring sites measuring variety of pollutants including sites Ozone (O_3). Nitrogen Oxide (NO), Sulphur Oxide (SO), Carbon Oxide (CO) from traffic in real using chemiluminescent (2015). In the same U.K with the help of chemical scientist, chemist identified trees as the source of high levels of organic pollutants during head waves. This unexpected result has improved the air quality forecast provided to the public in the U.K by taking into account natural emissions.

The world Health Organization (WHO) reported that around 7 million people died as a result of air pollution, by 2050 if they maintain current policies of improving air quality by reducing the rate of air pollution through minimizing activities resulting to global warming that lead to climate change but have not found a replacement for those activities that causes climate change. In my own opinion fossil energy should be replaced to eradicate global warming and climate change. Politicians globally are working at how to solve this problem, UN sustainable development goals including universal calls to action to protect life on land and water producing clean water and tackling climate change. The problems associated with air pollution is a serious issue in Nigeria

and continuously on the rise, this is because of the alarming increase in anthropogenic activities that adversely affects the climate and environment and most importantly the health of individual worldwide. Studies have revealed that the slightest

decrease in air pollution can lead to a significant increase in the peoples' health and increase the life expectancy of individuals worldwide. (Brunekreunal, 1997, Oguntoke 1998, Rouphoul, Frey, Colyar and Unal 2001, Oguntoke and Yusuf 2008). All these found association between exposures to atmospheric pollution has an adverse health effects such as increase in the number of hospitalizations and mortality and decrease in life expectancy.

2.0 LITERATURE REVIEW

Over the past several decades, the international and national research communities have developed a progressively clearer picture of how and why Earth's climate is changing and of the impact of climate change on a wide range in a human and environmental system. Research has also evaluated actions that could be taken and in some cases are already being taken to limit the magnitude of future climate change and adapt to its impacts (The national academies of Science Engineering Medicine, 2010). A considerable amount of kinetic studies has been carried out in this field. Consequently, progressive improvements in the data base for reactions involving atmospheric pollutants and the qualification of their atmospheric lifetime are made. This is fundamental to understanding the relationship between the budget and the trends of atmospheric pollutants and their impact on the climate. According to Holl, Reibeek
(2010) Global warming is the unusually rapid increase in Earth's average surface temperature over the past century primarily due to the greenhouse gases released by people burning fossil fuels. Greenhouse gases also occur due to the trapping of heat in the Earth's atmosphere.

Air pollution is the present of substances in the atmosphere that are harmful to the health of humans and other living beings or cause damage to the climate. As stated in Wilkipeadia, polluting substance is classified as either primary or secondary. Primary pollutants are relatively stable. They are formed at a particular source, rather than by transformation and reaction of the air. Because of this, primary pollutants may often be traced to their emission sources. They later can then be identified and regulated. The 4 class of primary pollutants includes particulate water, certain aromatic hydrocarbons, and various compounds particularly Oxides formed from sulphur, Nitrogen or Cation (Washinton University Law Review 1964). A recent study by Bloombery (2018) on Air pollution found that in many cases, the level of indoor pollution is five times higher than outdoor pollution. The sources of Air pollutants may be indoor or outdoor pollutants. Indoor pollutants such as radon gas, a carcinogen that escapes from the earth crust and become trapped in our home, building materials emit formaldehyde, smoke from stoves and firewood, pesticides and insecticides sprayed in our homes and carbon monoxide poisoning from our chimneys at home.

Air pollution is defined as the present in the outdoor or indoor atmosphere of one or more gaseous or particulate contaminants in qualities, characteristics and of duration that is injurious to human, plant or animal life or to property (Odigure, 1998). Pollutants can be in the form of solid particles, liquid droplets or gases. In addition, they may be natural or

manmade (Anderson, 2005). The continuous presence of these pollutants in the atmosphere eventually leads to climate change which occurs due to global warming.

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Air pollution poses major threat to the health of individuals in many West African countries like, Nigeria as well as other industrialized nations. About 1.1 billion lives are lost annually according to Aaron (2006). One of the worst cases of air pollution was the London Smog that occurred in 1952. It started on 4th December, 1952 and lasted until March of 1953. It was a major disaster that killed thousands of people and caused huge environmental problems. The use of dirty fuels and mitigate air pollution in London when; a cold fog descended on region and because the cold was so severe people burned more cold than usual. At that same time, the streets were overrun with diesel fuelled buses so that the pollutants emitted from these became trapped in the cold air there by increasing the concentration of greenhouse gases in the atmosphere. At first the Londoners hardly noticed this but in the ensuing weeks, over 8,000 people died from respiratory problems and so regulations had to be put in place to restrict the use of dirty fuels and mitigate air pollution.

In Nigeria, studies in the Niger Delta Area have indicated the prevalence of air pollution in most urban cities especially the Niger Delta Area of the Uyo metropolis of Akwa Ibom state. A study of Ana, Mynepalli, Sridhar and Bamgboye (2009). Environmental risk factors and health outcomes in selected communities of the Niger Delta Area Nigeria perspective public Health, argues that the people of this region depend on natural resources for their livelihood agriculture, fishing, forestry, hence pollution in these areas poses environmental and health risk. The area is situated in the Gulf of Guinea and is composed of four ecological zones coastal islands, mangrove swamps, forest water swamps and lowland forests. These different biomes make this region a well-endowed ecosystem and hence contain high concentration of biodiversity. Therefore, continuous pollution of these regions is crippling the economy, ecology environment and health of the area. The air quality present in these regions and in many industrialized nations today is consistent with emissions from industries, vehicles, gas flares, pipelines explosions, burning of bushes and refuses. These effects clearly show that the need for air pollution control cannot be over emphasized Bankal (2001), Ghia and Gaba (2000).

3.0 STUDY AREA

The study covered Kaduna which is presently the administrative capital of Kaduna state, one of the 36 states of Nigeria. The metropolis is the mid-point between Kano the commercial hub of Northern Nigeria and Abuja the Nation's capital. The name Kaduna as the metropolis was called is derived from two perspectives, while others say the name originated from the Gbagi tradition whom were the early settlers mean river with water, other opined that it originated from the word Kaduna meaning crocodiles in Hausa because of the predominance of crocodiles in the river which is a major landmark in the metropolis.

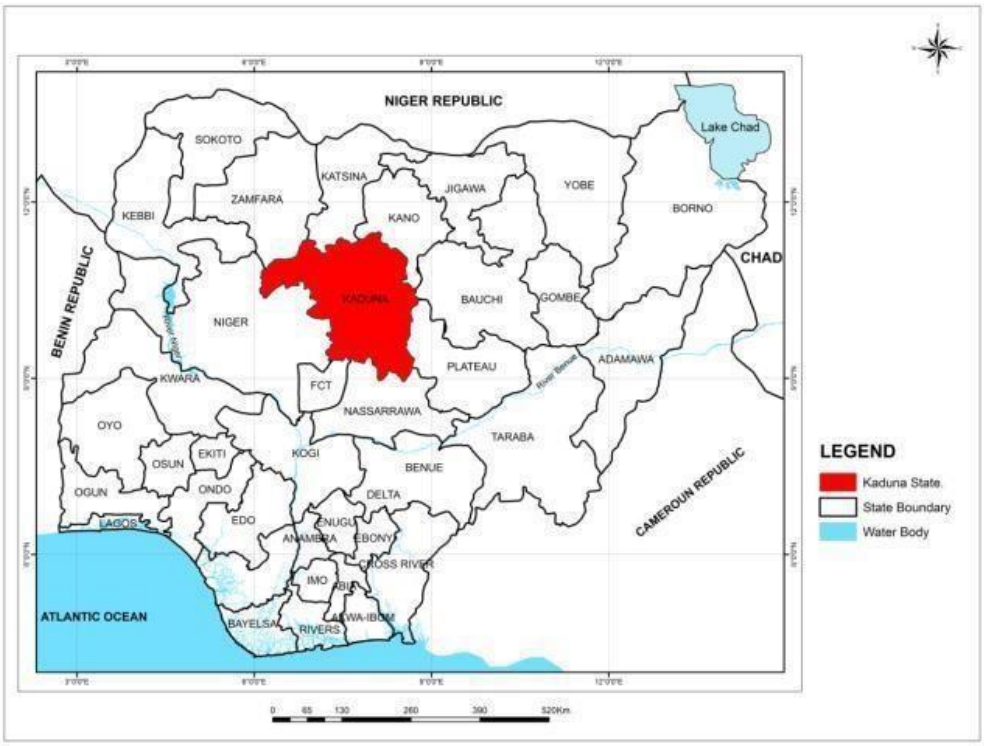
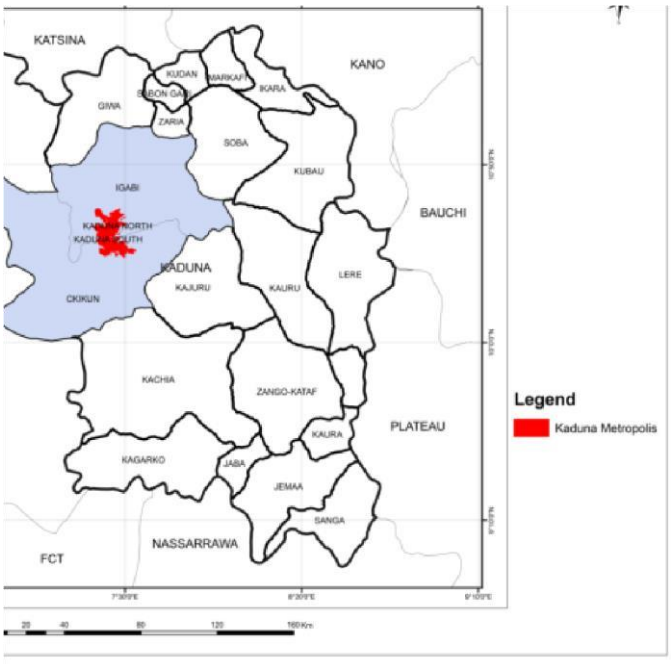


Figure 1.1 Map of Nigeria Showing Kaduna State



Source: Afon, and Alwadood, (2016)

Figure 1.2 Map of Kaduna State showing Kaduna Metropolis

Locationn

Kaduna Metropolis is located between Latitude 7^0 and 10^0 North of the equator and between Longitudes 7^0 and 10^0 East of the Greenwich Meridian (Alwadood, 2016). The metropolis is found in the North West of Nigeria and it is bounded by some states such as Kano, Katsina, Zamfara in the North, West by Niger state, East by Bauchi, Plateau and South by Nasarawa state and Abuja (FCT) with the total area of about 46km2 (see figure 1.2). It comprises of local government areas like Kaduna North, Kaduna South with segments of Chikun and Igabi local government areas (Mohammed, 2013) In 2006 Nigeria Census recorded about 760,084 people in Kaduna metropolis. In 2019 the population of Kaduna metropolis is projected to about 1,097,000 because of the rapid urbanization that has create increasingly large population growth (Wikipedia, 2019).

Kaduna metropolis lies on 613m above sea level. it is located within the tropics with temperature ranges of 25^0c-27^0c, rainfall has a wide variation. Kaduna metropolis experiences two main seasons, summer and winter and fall within Savanna classification of climate (Oguntoyinbo, 1983). Kaduna metropolis is under lain by a basement complex of igneous, sedimentary and metamorphic rocks mainly Jurassic to preCambrian ages essentially granite, gneisses, migmauties, schists and quartztes. Kaduna metropolis lie under the Northern guinea savanna vegetation belt with scattered trees and woody shrubs as well as extensive grass cover studies by journal of Natural sciences research (Mohammed A, Al-Amin, 2014).

4.0 METHODOLOGY

The various methods used in research as well as the population of the study, sampling techniques used in determining the sample size of the research, the instrument used and its validity, reliability of the instrument, procedure for data collection, procedure for data analysis are discussed.

This section deals with the background of the study area. The study area is Kaduna metropolis Nigeria. Also highlighted are the major environmental human settings that are relevant to this study.

Field work and observation research methods were used for the study since data characteristics were described using portable air pollutant detector;

i. MSA (equipment used for the study) Attair 5x gas detector.
ii. Chinaway (IN HAT 200) particulate counter. Frequency and average and no manipulations of data or variables were necessary.

The above mentioned instruments were administered to different points, this was supported by field work method. All these justify the research and make it valid and reliable.

a. The concentration level of some selected gaseous pollutants (Co, Co_2, No_2 and So_2) emission from motor vehicles movement at sample points.
b. Motor vehicle movement at sampled points within the city and control stations for visual understanding of the circumstances found on ground during the field survey.

The instruments that were used for this research are field work and observation method for processing acquired data. Portable gas monitor were used for field detection and recordings of concentration levels of emitted gases (pollutants) Co, Co_2, No_2 and So_2. It is a series of process through which a researcher test his/her system to verify the performance specifications published by the manufacturer of the instrument.

i. To ensure the amount of error present in the system won't affect the instrument performance, interpretation and result.
ii. To ensure that effects of shipment and storage did not affect the instrument performance.

Data for this study was collected from four sampling stations mapped out namely Command Junction, Refinery Junction, Sabo Market and Leventis round-about (Urban core) through the use of field test. The air pollutants were measured with a portable multi gas motor for detection of carbon monoxide (Co), Carbon dioxide (Co_2), Nitrogen dioxide (No_2), and Sulphur dioxide (So_2) and flammable gases which serves as the main source of primary data for the study. This unique instrument was rented from the Kaduna Environmental Protection Authority (KEPA). Other information was collected from text books, journals and other sources of data.

Various analytical tools and software such as bar charts, pie charts, tables and statistical package for social science software were used for this study.

5.0 RESULT AND DISCUSSION

Presentation and discussion of results of the data gathered in the course of this study. First the concentration and variation of pollutants (CO, CO_2, $N0_2$ and $S0_2$) measured across sampling points, and then followed by correlations among pollutants concentrations and traffic volume across sampling points.

Mean Concentration of Pollutants Per Day in Kaduna Metropolis Table 1.Mean Particulate at PM_{25} per Day across Sampling Points

Sample Point	Monday	Tuesday	Wednesday	Thursday	Friday
Command Junction	0.012	0.011	0.008	0.005	0.002
Sabon Tasha Market	0.018	0.07	0.014	0.010	0.06
Refinery Junction	0.004	0.007	0.09	0.001	0.005
Leventis Roundabout	0.016	0.012	0.006	0.008	0.004

Source: Field Survey (2021)

Table 1. show the result on mean daily (Monday to Friday) concentration of particulate PM_{25} across four sample points. The mean record of the particulate at the first sampled point ranges from 0.012ppm, 0.011ppm, 0.008ppm, 0.005ppm and 0.002ppm. The second sample point which is Sabo Tasha market revealed concentrations of 0.018pmm, 0.007ppm, 0.014ppm, 0.010ppm and 0.006ppm. Point three which was taken at refinery junction show concentration of 0.004ppm, 0.007ppm, 0.009ppm, 0.001ppm and

0.005ppm. The last point was at Leventis roundabout and has the following concentrations, 0.016ppm, 0.012ppm, 0.006ppm, 0.008ppm and 0.004ppm.

Table 2. Mean Particulate at PM_{10} per Day across Sampling Points

Sample Point	Monday	Tuesday	Wednesday	Thursday	Friday
Command Junction	0.048	0.054	0.026	0.017	0.020
Sabon Tasha Market	0.064	0.048	0.051	0.029	0.010
Refinery Junction	0.032	0.066	0.022	0.018	0.013
Leventis Roundabout	0.113	0.098	0.074	0.88	0.043

Source: Field Survey (2021)

The mean daily concentration of particulate PM_{10} is shown in table 4.2 where the record of the first point was taken at Command junction; the concentrations are 0.048ppm, 0.054ppm 0.026ppm, 0.017ppm, and 0.020ppm. The records at the second point are 0.064ppm, 0.048ppm, 0.051ppm, 0.029ppm and 0.010ppm. Point 3 records were taken at Refinery junction with 0.032ppm, 0.066ppm, 0.022ppm,, 0.018ppm and 0.013ppm. The last point was taken at Leventis roundabout with daily records of 0.113ppm, 0.098ppm, 0.074ppm, 0.088ppm and 0.043ppm.

Table 3. Mean Nitrogen Oxide ($N0_2$) level per Day across Sampling Points

Sample Point	Monday	Tuesday	Wednesday	Thursday	Friday
Command Junction	0.023	0.016	0.019	0.028	0.007
Sabon Tasha Market	0.043	0.026	0.015	0.008	0.024
Refinery Junction	0.011	0.022	0.009	0.010	0.007
Leventis Roundabout	0.030	0.027	0.018	0.008	0.003

Source: Field Survey (2021)

The results for $N0_2$ levels per day as presented in table 4.3 ranges from 0.023ppm, 0.016ppm, 0.019ppm, 0.028ppm, and 0.007ppm. Point 2 ranged from 0.043ppm, 0.026ppm, 0.015ppm, 0.008ppm and 0.024ppm. Point 3 ranges from 0.011ppm, 0.022ppm, 0.009ppm, 0.010ppm and 0.007ppm. Point 4 ranges from 0.030ppm, 0.027ppm, 0.018ppm, 0.008ppm and 0.003ppm.

Table 4. Mean Sulphuroxide ($S0_2$) Levels per Day across Four Sampling Point

Sample Point	Monday	Tuesday	Wednesday	Thursday	Friday
Command Junction	0.000	0.000	0.000	0.000	0.000
Sabon Tasha Market	0.000	0.000	0.000	0.000	0.000
Refinery Junction	0.000	0.000	0.000	0.000	0.000
Leventis Roundabout	0.000	0.000	0.000	0.000	0.000

Source: Field Survey (2021)

The result for $S0_2$ levels per day as presented in table 4.5 ranged 0.000ppm for all the four sample point.u

Table 5.Mean Cabondoxide (CO) Levels per Day across Sampling Points

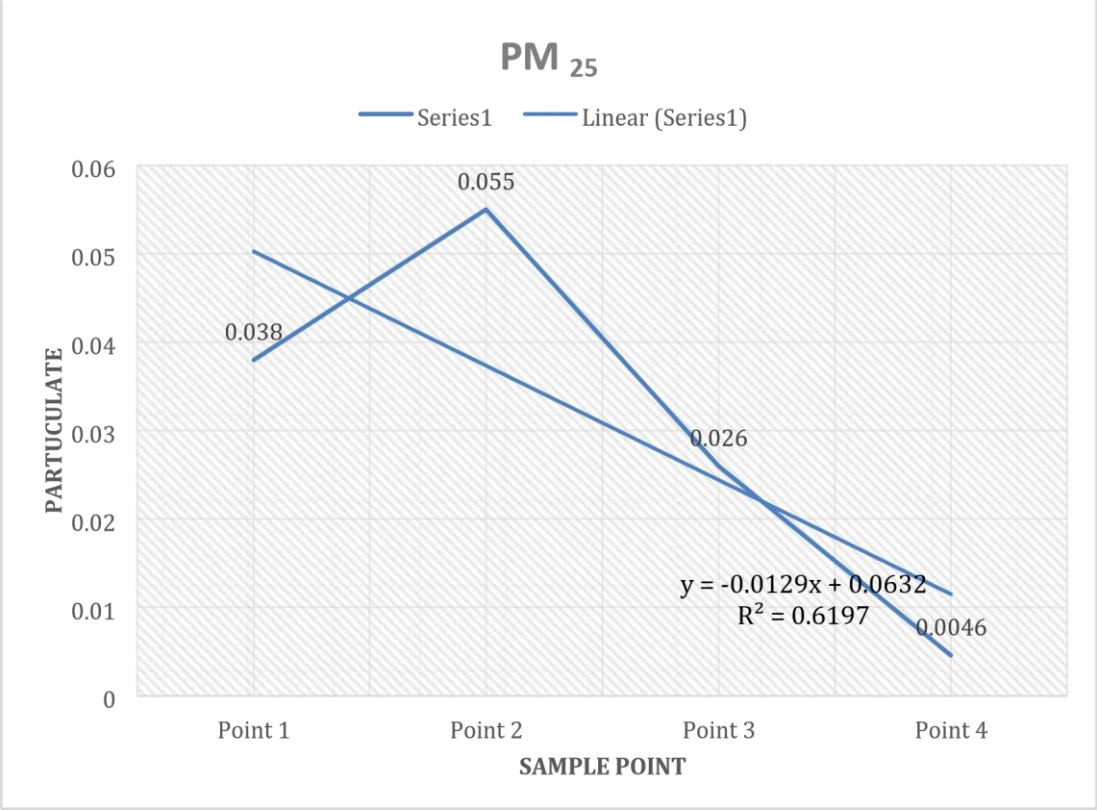
Sample Point	Monday	Tuesday	Wednesday	Thursday	Friday
Command Junction	0.03	0.01	0.04	0.00	0.04
Sabon Tasha Market	0.06	0.08	0.03	0.01	0.02
Refinery Junction	0.02	0.04	0.00	0.03	0.06
Leventis Roundabout	0.32	0.17	0.14	0.21	0.13

Source: Field Survey (2021)

The results for $C0_2$ levels per day as presented in table 4.5 ranges from 0.03ppm, 0.01ppm, 0.04ppm, 0.00ppm, and 0.04ppm. Point 2 ranged from 0.06ppm, 0.08ppm, 0.03ppm, 0.01ppm and 0.02ppm. Point 3 ranges from 0.02ppm, 0.04ppm, 0.00ppm, 0.03ppm and 0.06ppm. Point 4 ranges from 0.32ppm, 0.017ppm, 0.014ppm

The concentrationn to FMEnv and NESREA limit were discussed in figure 1 to figure 3 below.

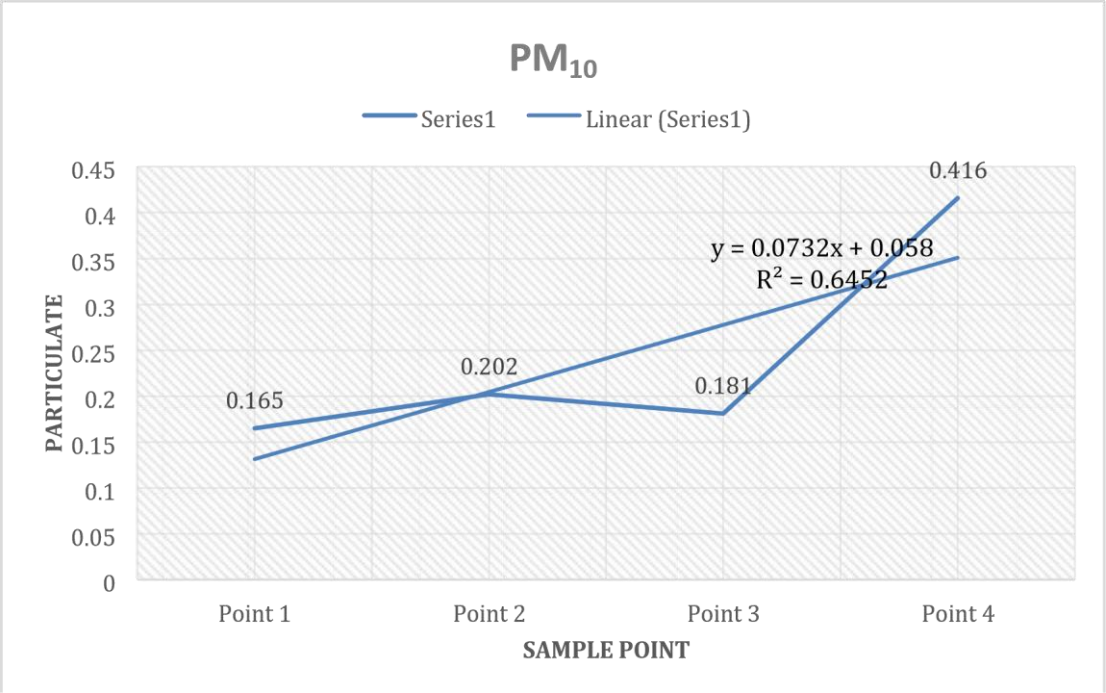
4.2.2 Trends of Physico-chemical Pollutants



Source: Author's Field Survey (2021)

Figure1. Concentrations of Particulate $PM_{2.5}$

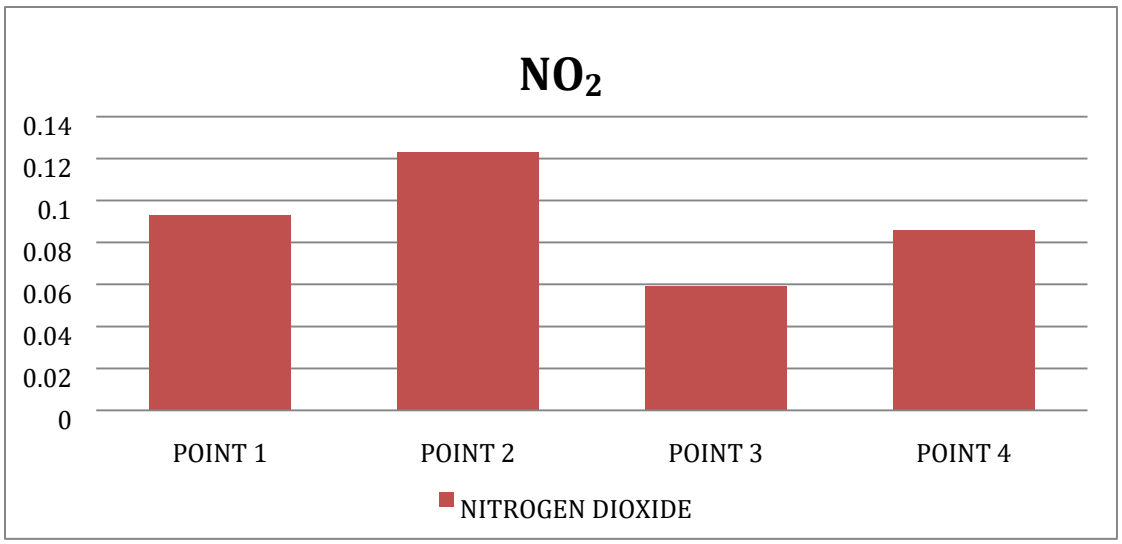
Concentration level of particulate is shown in figure 4.1 above. The value of $PM_{2.5}$ at point 1 is 0.038ppm, Point 2 is 0.055ppm, point 3 is 0.026ppm and point 4 0.0046ppm respectively. Therefore, $PM_{2.5}$ value were within the FMEnv and NESERA daily average limit of 100ppm which signifies that the particulate does not has effects at the point which the record were taken.



Source: Author's Field Survey (2021)

Figure2. Concentrations of Particulate PM_{10}

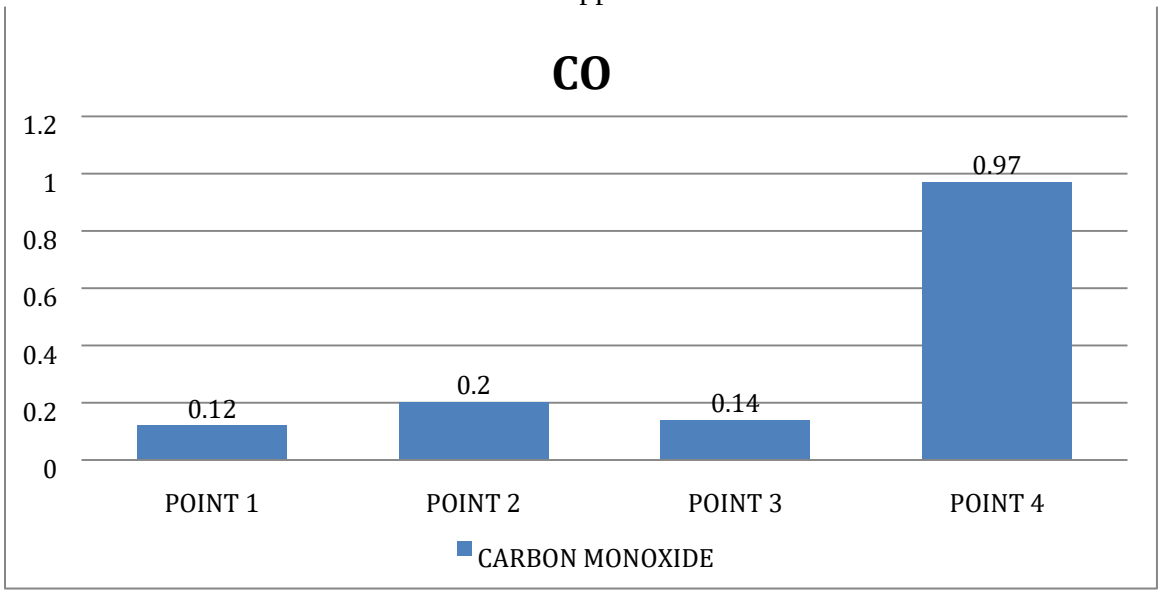
Figure2. is on the concentration of PM_{10}. The records at points 1 to 4 are as follows; 0.165ppm, 0.202ppm, 0.181ppm, and 0.416ppm respectively. Therefore, the values PM_{10} across the 4 points were within the FMEnv and NESERA daily average limit of 100ppm. This implies that it is within the range of no effect.



Source: Author's Field Survey (2021)

Figure3. Concentration of NO_2

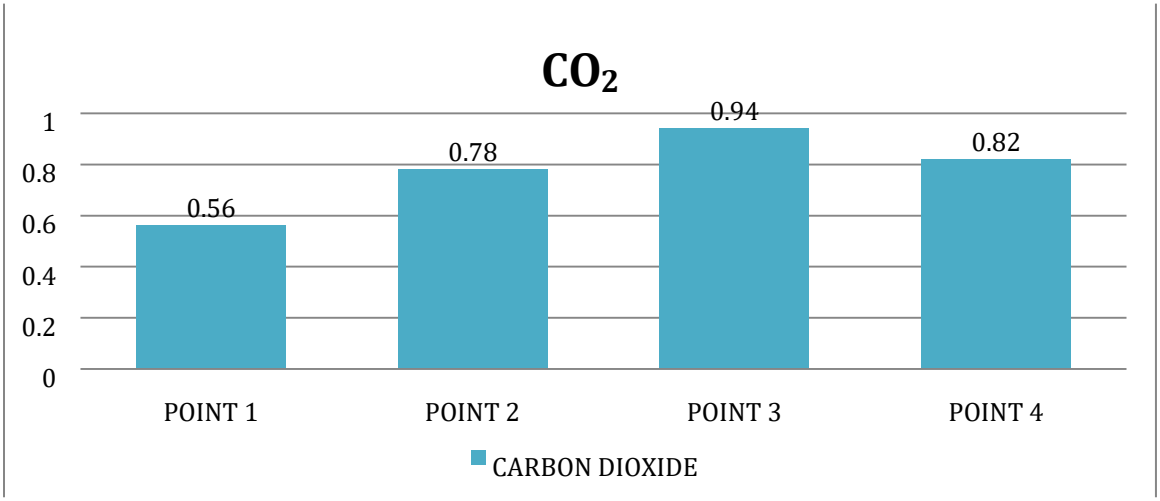
Concentration of Nitrogen dioxide points 1 to 4 revealed that point 1 has the concentration of 0.093ppm, the concentration at point 2 is 0.202ppm, point 3 has the concentration of 0.059ppm and point 4 is 0.086ppm. The concentration levels of NO_2 at point 1, 2, 3 and 4 are above the FMEnv and NESREA limit of 0.008ppm



Source: Author's Field Survey (2021)

Figure4. Concentration of SO_2

Figure 4 gives analysis on the concentration of carbon monoxide at points 1 to 4. The concentration of CO at point 1 is 0.12ppm, point 2 has the concentration of 0.20ppm, point 3 has the concentration of 0.14ppm and point 4 has a concentration of 0.97ppm. The concentration levels of CO at the points are all within the FMEnv and NESREA limit of 1.0-5.0ppm



Source: Author's Field Survey (2021)

Figure 5.Concentration of Carbon Dioxide CO_2

Figure 4.4 analyse the concentration level of carbon dioxide at points 1 to point 4. The concentration of point 1 is 0.56ppm, point 2 is 0.78ppm, point 3 0.94ppm and point 4 0.82ppm. The concentration of level of CO_2 is within the average limit of FMEnv and NESREA limit.

6.0 CONCLUSION AND RECOMMENDATION

The overall situation regarding motor vehicles emission in Kaduna metropolis is poor with a potentials environmental and human health effect. The results revealed that motor vehicles emission in Kaduna metropolis especially the urban core include pollutants like CO, CO_2; NO2 levels were measured at all the sampling points and the results were found concentrated with the exemption of SO_2 concentration results which was 0.000ppm. Therefore, in this aspects air quality is poor and hazardous for health. This implies that motor vehicles emission within the metropolis is not within safe limits. Hence, the results revealed that gaseous pollutants in the air such as CO, CO_2 and NO_2 directly or indirectly threaten the environment and life of inhabitants of Kaduna metropolis and that motor includes emission and others related activities carried out along these roads remain the dominant source of these pollutants. Therefore, this study also concluded that gaseous emission has significant effect on human health and environmental quality.

Based on the findings and conclusion of this study, the following recommendations were made;

i. The pollution levels and environmental implication detailed in this study, it is important to initiate a monitoring team and develop policies to reduce the emission and protection of the environment for sustainable development.
ii. There is a need to construction of inner roads and bridges that connect Kaduna North and South which are of important through reduction in the number of vehicles on major roads, thereby help to control, reduce the levels of pollutants and traffic jam at respective points.
iii. Motorization growth showed should be largely checked by environmental Regulation therefore, NESREA should review its air quality standard limit because looking at other air quality index of developed countries revealed that a high variation, also air quality database within the country need to be developed urgently and made readily available and accessible to all stakeholders.

This study which assesses the contribution of pollution to climate changes has immense contributions. The findings, recommendations and suggestions made is useful to those who will like to replicates this study or study of the nature. The following will serve as contributions to knowledge.

Findings of this study revealed the types and concentrations of pollutants in Kaduna Metropolis. This pollutants includes; Nitrogen dioxide (NO_2), Sulphurdioxide (SO_2), Carbon monoxide (CO) and Carbon dioxide (CO_2). The study also revealed that the existence of these atmospheric elements (NO_2), (SO_2), (CO) and (CO_2) are within the acceptable limit recognized by FMEnv and NESREA except NO_2 which was found to be above the limit. The result implies that the concentration of the elements most especially NO_2 pose a serious threat to climate change and this calls for expedient measure to curb and device measure tackle the menace of climate change for environment sustainability.

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