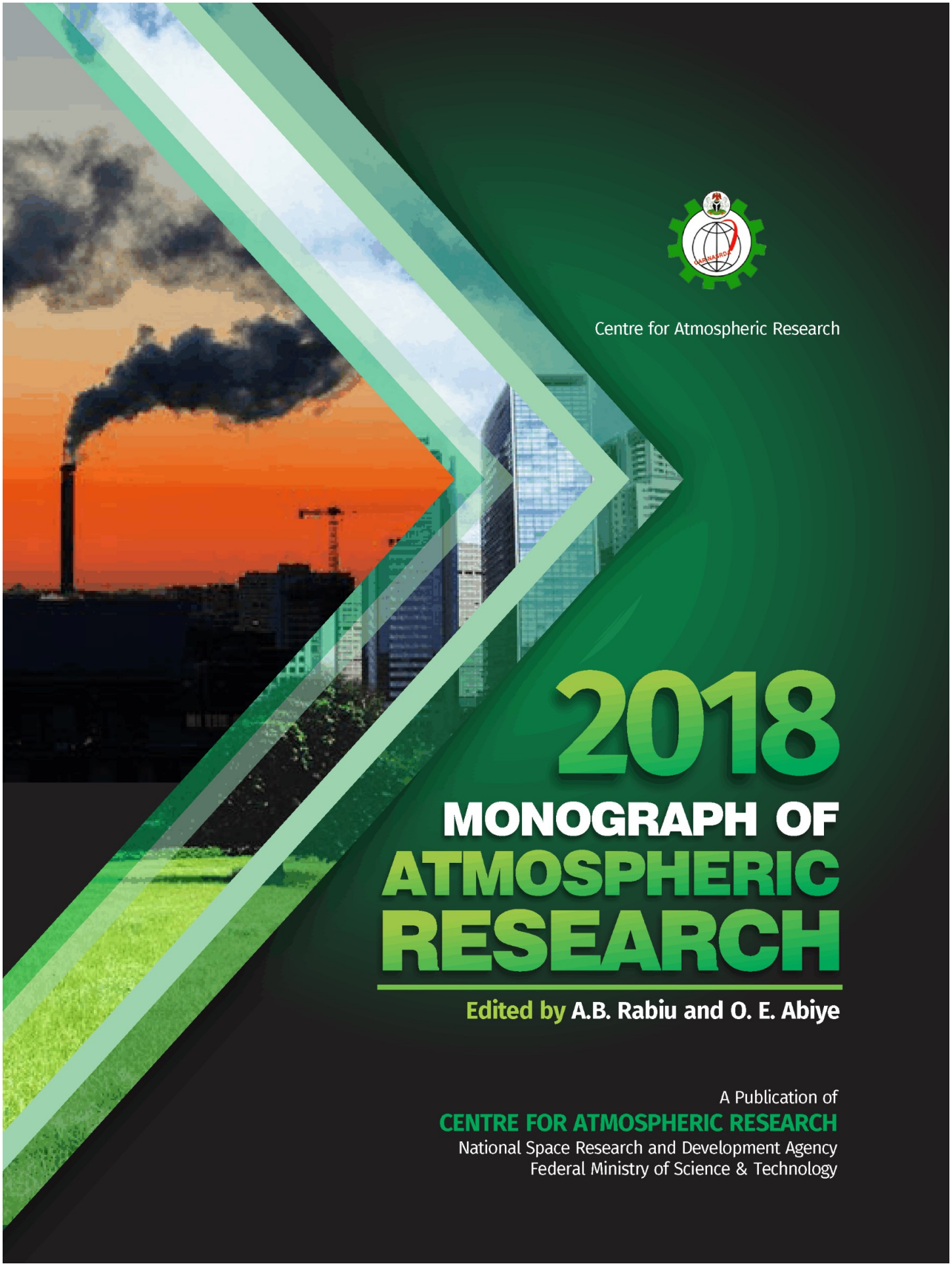

Centre for Atmospheric Research

2018 MONOGRAPH OF ATMOSPHERIC RESEARCH

Edited by A.B. Rabiu and O. E. Abiye

A Publication of
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PREFACE

The Centre for Atmospheric Research was established in January 2013 with a compelling mission to improve our understanding of the behaviour of the entire spectrum of the Earth's atmosphere; promote capacity development in relevant atmospheric sciences as a way of facilitating international competitiveness in research being conducted by atmospheric scientists; and disseminate atmospheric data/products to users towards socio-economic development of the Nation. CAR's extant core research focus includes: space weather, tropospheric studies, atmospheric research software and instrumentation development, microgravity and human space technology, and atmospheric chemistry and environmental research.

Pursuant to the above, The *Monograph of Atmospheric Research* published by the Centre for Atmospheric Research (CAR), is a collection of peer-reviewed manuscripts in Atmospheric Sciences and closely related fields. This maiden edition comprises articles presented during two separate workshops; *1st National Workshop on Microgravity and Environmental Research* (26 - 29 November, 2017) and *1st National Workshop on Air Quality* (13 - 16 March, 2018). Such workshops are integral part of CAR's capacity building program and they were primarily aimed at advancing the course of atmospheric research in Nigeria towards sustainable development. The Microgravity workshop was geared towards introducing new research opportunities in space life science by simulating microgravity conditions here at the earth's surface as a means of investigation space biological environment. The Air Quality workshop was organized in collaboration with Ministry of Environment and Nigerian Meteorological Agency (NIMET). The workshop analysed current Air Quality scenario in Nigeria, explored new opportunities for collaborative research and offered novel means of improving the present quality of life of the populace without jeopardizing the chance of the future generation. Cumulatively 196 participants participated in these two workshops and about 52 articles were eventually submitted for publication consideration in this monograph. The twenty-one articles in this very monograph are the articles that eventually made it through the rigorous peer-review process. We remain grateful to the reviewers for doing thorough work on the articles.

Thus, we are very pleased to present the *2018 Monograph of Atmospheric Research* which contains twenty-one articles, including some review papers, to readers in all spheres of interest across Nigeria and beyond. It is our hope that this effort will continue and will serve as a reference to atmospheric researchers in Nigeria.

Prof. A. B. Rabiu and Dr. O. E. Abiye,
Editors

Centre for Atmospheric Research

Assessment of air quality levels in heavy traffic areas in Enugu Urban, Nigeria

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ABSTRACT

This study assessed air quality levels in heavy traffic areas of Enugu Urban based on four air pollutants, namely: Carbon Monoxide (CO), Hydrogen Sulphide (H_2S), Nitrogen Oxide (NO), and Nitric Oxide (NO_2). Purposive sampling was employed in this study. These pollutants were measured in the field using ALTAIR 4X (Multi gas detector). Data collected were analysed using analysis of variance (ANOVA). Reference to NESREA/USEPA standards was the premise for air quality assessment. The results indicate that air quality varied among the three Local Government Areas (LGAs) of the study area with Enugu North LGA as the most polluted followed by Enugu South. Air pollution was caused by CO and NO as these two pollutants occurred in average concentrations of 114 ppm and 173.8 ppm, respectively higher than the NESREA/USEPA standard of 35ppm and 0.0053ppm, respectively for Enugu North LGA. The study reveals that the air pollution results correlate with traffic density of the study area indicating that vehicular emission is most likely to be the cause of air pollution in the study area. Ease of traffic by more access roads or better traffic control in the polluted area could abate the pollution incidents.

Key words: Air quality, Heavy traffic areas, NESREA/USEPA standards, Pollutants, Enugu urban

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INTRODUCTION

Man's immediate environment comprises of air on which all forms of life depends. Air is a mixture of gases, which composition by volume is approximately Nitrogen 78.1%, Oxygen 20.93%, and Carbon dioxide 0.03%. The balance is made up of other gases which occur in traces such as argon, neon, krypton, xenon and helium. In addition to these gases, air also contains water vapour, traces of ammonia and suspended particulate matter such as dust bacteria, spores and vegetable debris *(Majra, 2011).*

Man in his quest for development and growth has altered his environment greatly. From industrial revolution in the 19th century till date, the earth as a biosphere has experienced the negative impacts of environmental degradation and pollution at a rate faster than in the past centuries *(Abram, et al., 2016)*.

Good air quality is the degree which air is clean, clear and free from pollutants such as smoke, dust and smog and other gaseous impurities in the air. Poor air quality could have adverse effect on the environment and public health. Air quality can be degraded by natural or anthropogenic means. Natural means include volcanic eruptions, wind, storm, dust etc. whereas anthropogenic means include gaseous and particulate emissions from moving vehicles, fossil fuel powered plants, and burning of wood or other combustible materials in open air (Campbell, 1994).

World Health Organization *(WHO, 2006)* estimates that dirty air kills more than half a million people in Asia and Africa each year of which burden falls heaviest on the poor, similarly Mari, (2010) in his study of Atmospheric Composition of West Africa affirms that In Africa, hundreds of thousands of people in urban areas get sick just by breathing the polluted air that surrounds them *(Mari, 2010).*

Observations made during the African Monsoon Multidisciplinary Analyses *(AMMA)* campaign showed that anthropogenic combustion emissions, mainly linked to traffic and the use of bio fuels in western Africa, have a significant impact on urban air quality *(Mari, 2010)*. Air pollution from African cities is set to increase dramatically over the next two decades. In September 2012, the World Meteorological Organization *(WMO)* and International Global Atmospheric Chemistry (IGAC) project published the first international assessment of available information on air pollution in major urban agglomerations *(Megan Paul,Allen, Mark,and Jeff 2012)*. The summary of the report identified air pollution as a serious problem across the world and pointed out the existence of opportunities to translate knowledge from well-researched urban areas to less researched ones. The report stressed the fact that controlling air pollution is as significant as the mitigation of climate change.

Today, there is undoubtedly a high rate of atmospheric pollution in Nigeria especially in the industrial areas. For example, the air over Lagos, where about 38% of the manufacturing industries in the country are located, has been characterized by unpleasant odour since 1983. The Niger-Delta region of Nigeria where oil and gas are produced is another obvious example *(Avwiri and*

Ebeniro, 1998). These pollutants are emitted in the form of gas, and particulate matter *(Rao and Rao, 2001)*. Nigeria, considered as the giant of Africa, is highly bedevilled with environmental problems such as deforestation, climate change, desertification etc. Like in most other countries, these environmental problems are exacerbated by urbanisation, industrialisation and population growth, with the urban environments contributing increased particulate matter (PM_{10}) to air pollution problems *(Efe, 2006)*. Most commuters and urban dwellers are constantly exposed to the hazard of particulate matter, especially motorbike "Okada" riders and their passengers, and those who live close to the traffic clogged areas. Thus, urban inhabitants are typically plagued by a series of complaints including eye irritations and respiratory problems *(Efe, 2006)*. In Nigeria, the effect of particulate matter (air pollution) on human health has been noted by several scholars. For instance, *Nwachukwu and Ugwuanyi (2010) and Efe (2006)*, asserted that high rates of respiratory diseases occasioned by increased PM_{10} concentrations were experienced by residents of most urban areas unlike their rural counterparts. *Efe, (2006)*, noted that residents of Refinery Road, commercial areas, traffic-clogged areas and high-density residential areas in the Warri metropolis were the most affected, with over 15% of the cases recorded among infants and school children in Benin City, Ibadan, Kano and Port Harcourt.

In Enugu urban, there has been a significant development activity in the automobile sector, in terms of sharp increase in vehicular population *(Enete and Ogbonna, 2012)* . Unlike the rural areas, this has probably overwhelmed the cities carrying capacity for air pollutants like NO_x, SO_2, CO, H_2S, particulates and lead. The impact of such anthropogenic activity could be responsible for variety of diseases on both human and plant communities (*Enete and Ogbonna, 2012*). From the above, it is anticipated that air pollution in Enugu urban could become a major public health problem if adequate mitigation measures are not taken at this time, because of the alarming increase in both population and vehicular traffic. Arising from the observed increase vehicular traffic in Enugu urban, this study therefore assessed the air quality levels in heavy traffic areas of Enugu urban, with the major objective of evaluating the air quality indices of the heavy traffic areas of Enugu urban.

MATERIALS AND METHODS

Description of study area

Enugu urban, in South-eastern Nigeria, is the capital of Enugu State and is 93 km (58 mi) northeast of Onitsha. It lies at the South-eastern foot of the Udi hills. Enugu urban is a major coal mining, administrative, educational, and trading centre of Enugu State. The present Enugu urban was founded in 1909 after coal deposits were discovered at the nearby village of Enugu called Ngwo, Subsequently Enugu urban became an administrative centre after the rail road to Port Harcourt was completed in 1912 (*Enete et al., 2012*). Enugu (*7°26E, 6°19N*) was once the administrative capital of the defunct Eastern Nigeria until the late 1970's when it was decentralized. It is economically vibrant and arguably has the most educated workforce in the south eastern geopolitical zone of Nigeria with official population of about 3million (*Nwadiogbu et al, 2013*).

Sample Collection

Six heavy traffic locations was selected from each local government area, giving rise to eighteen (18) vehicular traffic areas selected for the study area. Primary data were collected from field measurements of gaseous pollutants emitted into the atmosphere as a result of man-made activities and natural occurrences. The pollutants were measured using multi gas monitor, ALTAIR 4X. The ALTAIR 4X is an extremely durable multi gas detector that simultaneously measures up to four gases namely CO, H_2S, NO and NO_2.

Field procedure and statistical techniques

At any given location the multi gas detector was exposed to the environment for at least 20 – 30 minutes. Then the detected pollutants (CO, H_2S, NO and NO_2) recorded in part per million (PPM). The instrument was turned off after taking reading for each location. Global Positioning System (GPS) was also used in taking the coordinates of each sampling location (Table 1).

The map of the sampling location for the study area is shown below Figure 1. During data collection, two research assistant teams were employed to cover the study area morning and evening for a period of three days. Each of the team had the instrument, as they get to the study location, reading was taken at an allocated time, recorded and the instrument turned off before they proceed to the next location, because of limited resource and research assistance, only two teams was used, and this affected the time of data collection in Enugu North, that they had to start from afternoon, instead of starting in the morning hours that others started. Data collected were summarised and presented. The data were analysed by testing the hypothesis formulated in conformity with the objective of the study. Analysis of variance (*ANOVA*) was used to test the hypotheses.

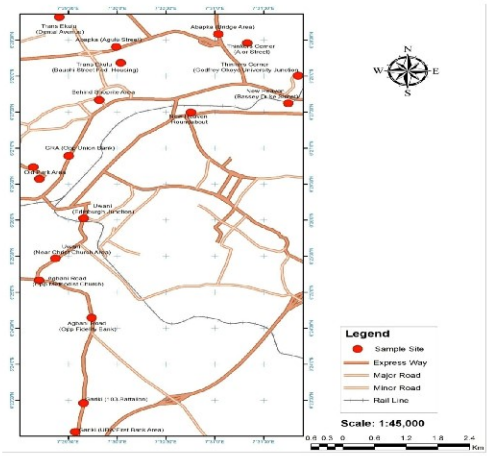

Figure 1: Map of Sample locations in Enugu Metropolis

Table 1: The study locations and coordinates

CODE	LGA	LOCATION	GPS
EN1	Enugu North	Holy Ghost Ogbete Area	6.261505°N 7.291704°E
EN2	"	Old Park Area	6.260808°N 7.292200°E
EN3	"	GRA (Opp Union Bank)	6.448209°N 7.491761°E
EN4	"	Behind Shoprite Area	6.4611623°N 7.496975°E
EN5	"	New Heaven (Bassey Duke Street)	6.627241°N 7.305402°E
EN6	"	New Heaven Roundabout	6.625520°N 7.284904°E
ES1	Enugu South	Gariki (UBA/First Bank Area)	6.383968°N 7.493247°E
ES2	"	Gariki (103 Battalion)	6.391021°N 7.494292°E
ES3	"	Agbani Road (Opp Fidelity Bank)	6.410776°N 7.495663°E
ES4	"	Agbani Road (Opp Methodist Church)	6.419413°N 7.486669°E
ES5	"	Uwani (Near Christ Church Area)	6.424484°N 7.489495°E
ES6	"	Uwani (Edinburgh Junction)	6.433748°N 7.494285°E
EE1	Enugu East	Trans Ekulu (Dental Avenue)	6.482481°N 7.4914561°E
EE2	"	Trans Ekulu (Bauchi Street Fed. Housing)	6.284404°N 7.303507°E
EE3	"	Abapka (Bridge Area)	6.476344°N 7.517300°E
EE4	"	Abapka (Agulu Street)	6.284305°N 7.303901°E
EE5	"	Thinkers Corner (Alor Street)	6.474321°N 7.522231°E
EE6	"	Thinkers Corner (Godfrey Okoye University Junction	6.280303°N 7.320204°E

RESULTS AND DISCUSSIONS

It was observed that hydrogen sulphide appeared to be zero (0) at all locations. Therefore H_2S is not a potential gaseous pollutant in Enugu Urban. Nitrogen dioxide (NO_2) appeared to be constant throughout the measurement period whereas carbon monoxide (CO) varies significantly irrespective of the locations with the highest value of 114 ppm at Old Park Area and Uwani (*Edinburgh Junction in Enugu North*) and lowest value of 15 ppm at Trans Ekulu Dental Avenue and Banchi street Federal Housing (*Enugu East*). Nitric oxide (NO) showed same behaviour like CO with the highest value of 173.83 and least value of 28.3ppm at same locations.

At the second day of the field work, H_2S was still undetected while NO_2 appeared to be constant throughout the day. CO and NO concentration values reduced drastically when compared with the 1st day of the field work. CO highest and lowest concentration values were 105 and 10 ppm at Old Park Areas and Trans Ekulu Dental Avenue respectively.

At the 3rd day of the field work, the trend of the pollutants followed same pattern as that of first and second day of the field work. H_2S concentration was still zero (O) and NO_2 was constants too with average value of 1.375 PPM. CO was measured to be 114 ppm at Agbani Road opposite Fidelity Bank (extreme heavy traffic area) and 30 ppm at Abakpa Agulu street as the highest and lowest value respectively while NO was measured 173.80 and 50.35PPM at same location with CO as the highest and smallest values respectively. From the three days intensive measurement of the study area, it is deduced that CO, NO and NO_2 are the major pollutants in the study area. NO_2 appeared to be constant throughout the study while as CO is increasing, NO also increases.

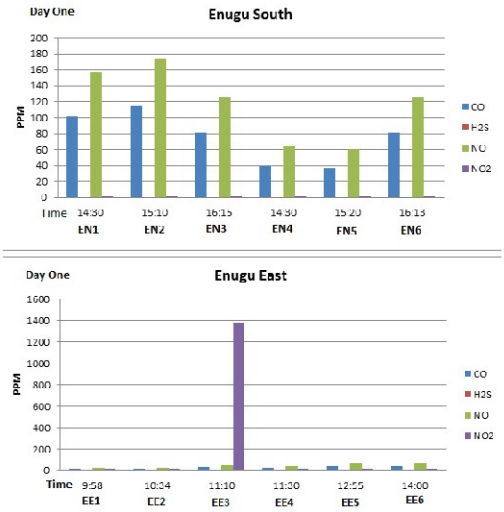

Figure 2: Bar Chart showing the levels of pollutants on day one (11 August 2017)

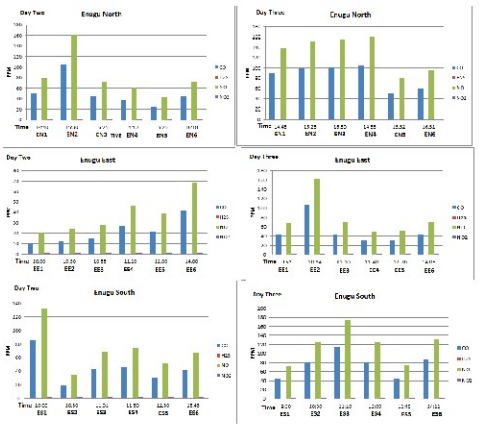

Figure 3: Bar Chart showing the levels of pollutants on day two and three (12 and 14 August, 2017 respectively)

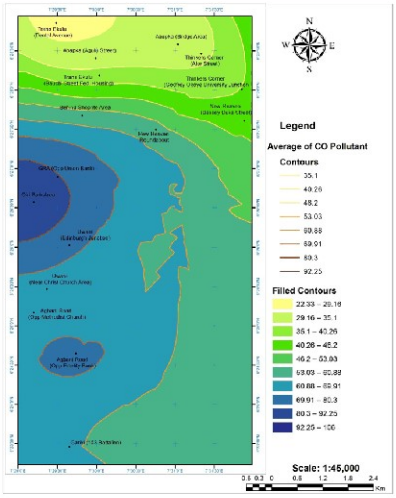

Figure 4: Spatial dispersion of CO pollutant in Enugu Metropolis

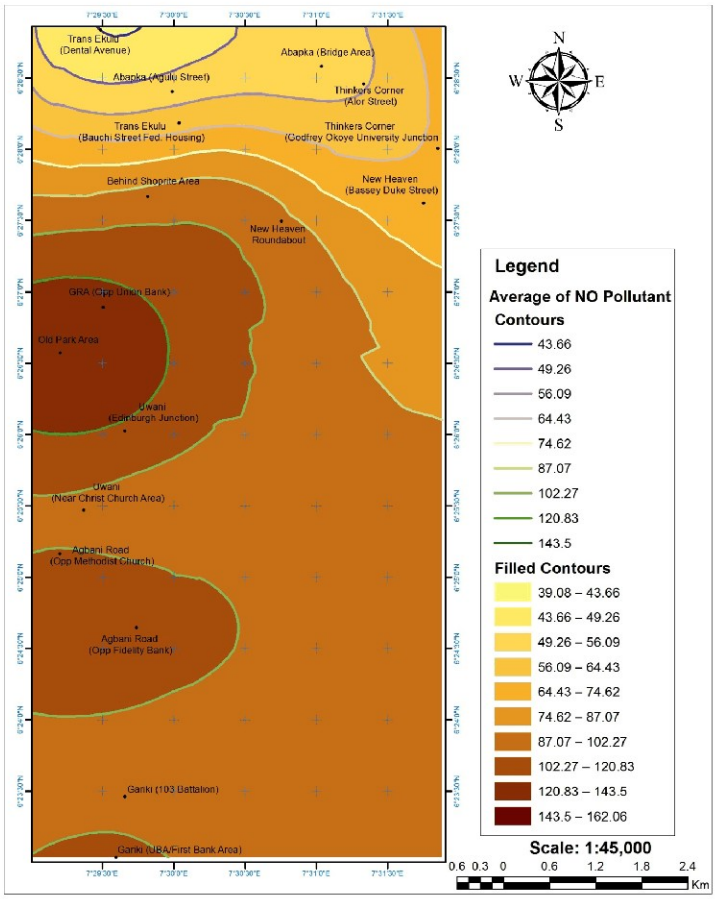

Figure 5: Spatial dispersion of NO pollutant in Enugu Metropolis

CONCLUSIONS

The tremendous increase in mobilization of human society has resulted in phenomenal rise in vehicular traffic on the major roadways. The study concludes that air pollution within Enugu Urban varies significantly from one LGA to another. Enugu North was more polluted than the two other LGA (Enugu south and Enugu east) because of heavy traffic in and around the Central Business District of the Enugu located in Enugu North followed by Enugu South and Enugu East. The pollutants that are more pronounced in the study area are NO, CO and NO2. This shows increase in vehicular, commercial and industrial activities in the metropolis. Hence, there is need for urgent air quality management strategies, especially in the industrial area within the study area.

Acknowledgement

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Conflict of Interest

Authors hereby declare that there is no competing interest(s) of personal, professional or financial nature which may otherwise potentially jeopardize the credibility of this work.

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Our Mandates

The Center for Atmospheric Research, CAR, is a research and development center of NASRDA committed to research and capacity building in the atmospheric and related sciences. CAR shall be dedicated to understanding the atmosphere—the air around us—and the interconnected processes that make up the Earth system, from the ocean floor through the ionosphere to the Sun's core. The Center for Atmospheric Research provides research facilities, and services for the atmospheric and Earth sciences community.

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