ASSESSMENT OF AIR QUALITY AND NOISE LEVELS IN THE UNIVERSITY OF BENIN, UGBOWO CAMPUS.

BY

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CERTIFICATION

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DEDICATION

I dedicate this project to God Almighty, whose grace, wisdom, and strength have guided me through every step of my academic journey. His divine support has made the successful completion of this work possible.

I am exceedingly grateful to my parents, Mr. and Mrs. Ubuane, for their love, encouragement and sacrifices made on my behalf.

Lastly, I dedicate this work to all who played a role in supporting me throughout the course of this academic endeavor.

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ABSTRACT

This research examines air quality and noise pollution within the University of Benin, Ugbowo Campus, to determine how environmental factors influence the health, comfort, and productivity of individuals in the university community. With increasing urban activities, traffic congestion, and generator use across the campus, the issue of environmental pollution has become more significant. The study assessed four major air pollutants, particulate matter ($PM_{2.5}$ and PM_{10}), carbon monoxide (CO), and ozone (O_3), and evaluated noise levels in various campus zones to provide a comprehensive understanding of environmental quality in the study area.

Data were gathered using an air quality monitor and ozone meter for air pollutant measurement and an Extech sound level meter for noise. The Air Quality Index (AQI) was used to interpret pollutant concentrations, while Geographic Information System (GIS) mapping helped visualize spatial pollution patterns across the campus. Results showed that air quality across the campus ranged from good to moderate, with AQI values between 26 and 55. Cleaner conditions were recorded at the College of medical sciences and Halls 6 and 7 (26 – 31), while higher values occurred at ekosodin back gate, 55 and at Main gate,47, influenced by vehicular and commercial activities. $PM_{2.5}$, PM_{10} and CO concentrations were also higher at these gate areas, whereas ozone levels remained low reading from 0.01 – 0.07 ppm. In contrast, noise levels often exceeded standards in busy zones, reaching 86.7 dB(A) at ekosodin back gate and above 80 dB(A) in other active areas, surpassing the WHO daytime limit of 55 dB(A).

The study concludes that while the overall air quality on the University of Benin campus remains within acceptable limits, noise pollution presents a more serious challenge. To improve environmental conditions, the study recommends effective traffic regulation, proper control of generator use, expansion of vegetation and green zones, and consistent air and noise monitoring. These actions will enhance sustainability and ensure a cleaner, quieter, and healthier learning environment for all campus users.

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ACRONYMS

WHO – World Health Organization

USEPA – United States Environmental Protection Agency

FMEnv – Federal Ministry of Environment

NESREA – National Environmental Standards and Regulations Enforcement Agency

AQI – Air Quality Index

NNI – Noise and Number Index

GIS – Geographic Information System

UV – Ultra Violent

LGA – Local Government Area

EIA – Environmental Impact Assessment

NAAQS – National Ambient Air Quality Standards

UNEP – United Nations Environment Programme

CHAPTER ONE

INTRODUCTION

1.1 Background of study

In today's rapidly changing world, air pollution and noise pollution have become pressing issues, especially in urban and institutional spaces. This is especially true in developing countries such as Nigeria, where rapid urban growth often outpaces infrastructure and environmental management. Universities are increasingly affected by pollution due to growing human activity and vehicular traffic. However, despite the importance of a clean and quiet learning environment, air and noise pollution in university settings are often overlooked (WHO, 2021).

The University of Benin (UNIBEN), Ugbowo Campus, located in Benin City, Edo State, is a vibrant community. It houses not only lecture halls and libraries but also residences, markets, eateries, and administrative buildings. With all these daily activities comes noise and emissions, from cars, motorcycles, generators, ongoing construction, and large student gatherings. These contributes to rising levels of harmful pollutants such as particulate matter ($PM_{2.5}$ and PM_{10}), carbon monoxide (CO), and ground-level ozone (O_3), all of which are known to pose serious health risks. (NESREA, 2011; WHO, 2021)

For example, fine particles like $PM_{2.5}$ and PM_{10} can enter deep into the lungs and bloodstream, increasing the risk of respiratory and heart diseases. Carbon monoxide (CO), though odorless and invisible, reduces the oxygen carried in the blood. Ground-level ozone, which forms through chemical reactions in sunlight, can worsen existing respiratory issues and cause throat and eye irritation.

Unfortunately, there is limited research on how widespread these pollutants are in Nigerian universities, including the University of Benin. This study seeks close that gap by evaluating the air quality and nose levels in different areas of the Ugbowo Campus, with the goal of highlighting potential risks and offering possible solutions.

1.2 Statement of the problem

Over the years, the University of Benin has seen a noticeable rise in population and activity, due to the growing student enrollment, urban expansion, and expanding commercial activities within the campus. With more people and vehicles moving around each day, the campus environment faces increasing levels of air and noise pollution.

However, despite these visible changes, there is no existing data to show how much pollution students and staff are exposed to daily. Without such data, it is difficult to make informed decisions about health and safety on campus, or to implement effective policies to control pollution.

This research, aims to fill that information gap by providing a detailed assessment of the current state of air and noise pollution on campus. It will help identify problem areas, guide interventions, and support future environmental planning for a healthier university environment.

1.3 Aim and Objectives

The aim of this project is to assess the ambient levels of key air pollutants and environmental noise in various areas of the University of Benin, Ugbowo campus. The following are the objectives of this project:

i. To measure the concentration of criteria air pollutants and evaluate ambient noise levels across different zones of the campus.
ii. To compare the measured air and noise pollution levels with established national (NESREA) and international (WHO) standards.
iii. To identify pollution heat maps and recommend practical strategies for improving air quality and reducing noise levels within the university environment

1.4 Scope of study

This study focuses on various locations within the Ugbowo Campus of the University of Benin, reflecting the main areas where people live, learn, and interact. These include lecture theaters, libraries, hostels, staff residences, cafeterias, market areas, roads, and car parks.

The research will center on the following air pollutants; $PM_{2.5}$, PM_{10}, CO, and O_3. Portable air quality monitors will be used for air measurements, while sound level meters will record noise levels in decibels. The monitoring will take place during the day over short observation periods. However, factors like seasonal variation, indoor air pollution, and weather patterns will not be covered within the scope of this study.

1.5 Justification of the study

Universities are meant to be places that promote learning, health, and well-being. But when air quality is poor and noise levels are high, they can seriously affect the concentration, productivity, and overall health of student and staff (Clark & Paunovic, 2013).

Pollutants like $PM_{2.5}$, PM_{10}, CO, and O_3 have been linked to a wide range of health problems, from respiratory issues to heart conditions. This makes it important to study their levels in the University of Benin campus environment. By providing real data on air and noise pollution, this study will not only raise awareness but also guide the university and relevant authorities in creating a cleaner and quieter campus.

In the long run, the findings can support sustainable policies, improve campus infrastructure, and ensure a healthier atmosphere for everyone in the university community.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Environmental pollution has become one of the most pressing challenges facing the world today. From the air we breathe to the sounds we hear in our daily environments, pollution continues to impact both human health and the environment. Air and noise pollution are major types of pollution and are of growing concern especially in busy settings like university campuses, where people live, work, and study in close proximity to sources of emissions and noise.

Air pollution is caused by harmful gases and particles released into the atmosphere from sources such as vehicles, industrial activities, generators, and construction work. Common pollutants like $PM_{2.5}$, PM_{10}, ground-level ozone (O_3), and carbon monoxide (CO), have been linked to several health problems, especially respiratory and cardiovascular disease (USEPA, 2020). On the other hand, noise pollution, often overlooked, is equally dangerous. Prolonged exposure to loud or disturbing sounds can lead to stress, sleep disturbances, hearing loss, and reduced academic performance (Banser et al., 2014; Munzel et al., 2018).

In academic environments like the University of Benin, maintaining a healthy and comfortable atmosphere is essential for effective learning, research, and overall well-being. Students and staff spend long hours in lecture halls, hostels, offices, and other shared spaces, making them particularly vulnerable to the effects of poor air quality and excessive noise. Unfortunately, many campuses in Nigeria, lack regular monitoring of these environmental conditions.

This literature review aims to explore what air and noise pollution are, how they affect human health and the environment, and the standards used to measure and regulate them. It will also look at previous studies carried out locally and internationally to better understand the current state of knowledge, identify gaps, and lay the groundwork for assessing air quality and noise levels in the University of Benin, Ugbowo campus.

2.2 Air Pollution

2.2.1 Definition and Classification

Air pollution occurs when harmful gases, particles, or biological substances enter the atmosphere in amounts that can harm people, animals, plants, or even the environment. These pollutants may come directly from specific sources, called primary pollutants, or may form in the air through chemical reactions and they are known as secondary pollutants. For example, carbon monoxide (CO) is a primary pollutant that comes directly from engines and generators, while ground-level ozone (O_3) is a secondary pollutant formed when sunlight reacts with nitrogen oxides and volatile organic compounds in the air (Seinfeld & Pandis, 2016).

2.2.2 Main Sources of Air Pollution in Urban and Campus Settings

In urban areas and university environments like the University of Benin, air pollution comes from several sources. Vehicles moving in and out of the campus release exhaust fumes, while generators used during power outages emit large amounts of pollutants. Construction work, open waste burning, and laboratory activities also contribute to air pollution. Even daily activities like cooking with firewood or charcoal in residential areas near the campus can play a role (Ngele et al., 2021).

2.2.3 Air Pollutants Monitored

The most common and harmful air pollutants include:

i. Ground-level ozone (O_3)

ii. $PM_{2.5}$

iii. PM_{10}

iv. Carbon monoxide (CO)

These air pollutants are dangerous at high levels and are regulated by organizations like the World Health Organization (WHO), NESREA in Nigeria, and the Federal Ministry of Environment (FMEnv).

i. Ground-Level Ozone (O_3)

Ground-level ozone is not released directly into the air. Instead, it forms when pollutants from vehicles, generators, and other sources of combustion react together in sunlight. Unlike the ozone layer high up in the atmosphere which protects us from UV rays, ozone near the ground is very harmful. It can cause chest pain, coughing, throat irritation, and worsen conditions like asthma. High ozone levels often occur on sunny days when traffic and generator use are high (Manisalidis et al., 2020; WHO, 2021).

ii. $PM_{2.5}$

$PM_{2.5}$ simply refers to fine particulate matter that are of diameter 2.5 micro meters or less, meaning they are so small they cannot be seen with the human eye. These tiny particles can go deep into the lungs and even enter the bloodstream, posing serious health risks. Common sources include vehicle exhaust, generator smoke, and open burning of waste. Due to the size and harmful effects, $PM_{2.5}$ is one of the most closely watched pollutants in air quality studies (Pope and Dockery, 2006).

iii. PM_{10}

PM_{10} refers to slightly larger dust particles of diameter 10 micro meters or less, that are still small enough to be inhaled. They often come from road dust, construction sites, and unpaved paths and are especially common in and around university campuses during building projects. Although they don’t penetrate the lungs as deeply as $PM_{2.5}$, PM_{10} can still cause coughing, throat irritation, and respiratory discomfort (Brook et al., 2010).

iv. Carbon monoxide (CO)

Carbon monoxide is a colorless and odorless gas, nicknamed the "silent killer." It is mainly produced by engines and generators that burn fuel. On a campus like the University of Benin, CO can build up near hostels, cafeterias, or maintenance buildings where generators or fuel-powered equipment are used. Breathing in of CO can reduce the amount of oxygen that reaches the body's organs and tissues, leading to headaches, dizziness, and even death in severe cases (Raub et al., 2000).

2.2.4 Impacts of Air Pollution on Health, Environment, and Infrastructure

Air pollution affects more than just the air we breathe, it has various impacts. Health-wise, exposure to pollutants like $PM_{2.5}$ has been linked to heart disease, lung infections, asthma, and even early death (Pope and Dockery, 2006).

Environmentally, ground-level ozone can damage plant leaves and reduce food production (UNEP, 2021). Understanding these impacts is key to protecting both public health and the learning environment in universities.

2.3 Noise Pollution

2.3.1 Definition of Noise and Noise Pollution

Noise is simply any unwanted or disturbing sound. Sound is a natural part of life, noise becomes a problem when it interferes with daily activities, sleep, communication, or overall well-being. Noise pollution refers to prolonged or excessive exposure to such disruptive sounds that can negatively affect health and the environment (WHO, 2018).

Unlike other forms of pollution, noise does not leave visible residues. However, its effects can be just as damaging, especially in places like a university campus, where quiet environments are essential for concentration, communication, and rest. The World Health Organization considers environmental noise as one of the top environmental risks to physical and mental health, especially in urban settings (Basner et al., 2014).

2.3.2 Main Sources of Environmental Noise on Campus

On university campuses like the University of Benin, noise pollution comes from various sources. Some are external, such as traffic from busy roads near campus, while others are internal, and they are as follows:

i. Vehicular noise from student and staff cars, motorcycles, and shuttle buses.
ii. Generators, which are often used due to inconsistent electricity supply.
iii. Construction activities, particularly in expanding institutions like UNIBEN.
iv. Crowded environments, including cafeterias, markets, and student hostels.
v. Loudspeakers used during religious gatherings or social events.

These noise sources come and go, but when present, can be very loud, and their impact is felt more during the daytime when academic and social activities are at their peak (Oyedepo et al., 2012).

2.3.3 Effects of Noise on Human Health, Learning, and Concentration

Noise pollution not only causes annoyance but can have serious physical and psychological effects, especially in learning environments. Some of these effects include:

i. Hearing problems: Long-term exposure to high noise levels can lead to hearing loss, especially around constant sources like generators or loudspeakers (WHO, 2018).
ii. Stress and sleep disturbance: Continuous noise increases stress levels and can interfere with sleep, especially in residential areas of campus leading to poor sleep which affects the memory, learning ability, and emotional well-being (Basner et al., 2014).
iii. Reduced academic performance: Noise in lecture halls, or libraries can distract students, disrupt concentration, and affect verbal communication. Studies show that students in noisy

environments tend to perform worse in reading comprehension, memory tasks, and standardized tests (Shield & Dockrell, 2008).

iv. Mental fatigue and cognitive overload: Continuous exposure to background noise forces the brain to work harder to process information, leading to faster mental fatigue. This reduces the ability to focus during lectures. (Stansfeld & Matheson, 2003).

2.4 Air Quality Index (AQI)

2.4.1 Concept and Purpose of AQI

The Air Quality Index (AQI) is a tool used worldwide to simplify and communicate how clean or polluted the air is on a daily basis. Rather than listing concentrations of various air pollutants in technical units, the AQI converts this data into a single number or color-coded scale that is easy to understand. The main aim of the AQI is to let people know how safe or unsafe it is to be outdoors at various time (USEPA, 2018).

AQI focuses on criteria air pollutants known to have serious health effects, especially in urban and populated areas. These include ground-level ozone (O_3), $PM_{2.5}$, PM_{10}, and carbon monoxide (CO). In places like the University of Benin, where student and staff populations are high and exposure to vehicular and generator emissions is common, AQI provides a simple way to assess and compare air quality levels across different zones on campus.

2.4.2 Method of Calculation

The AQI is calculated based on the concentrations of the individual pollutants mentioned above. Each pollutant has a sub-index calculated using standard formulas that relate pollutant concentration to its health-based threshold levels. The highest sub-index among the pollutants is then reported as the overall AQI value for that location and time (Sharma et al., 2013).

The general formula used is:

Equation 2.1

$$Ip = \frac{IHi - ILO}{CHi} * Cp - CLo + ILo$$

Where:

Ip = AQI for pollutant p

Cp = measured concentration of the pollutant

CHi, CLo = the breakpoints that bracket Cp

IHi and ILo = AQI values corresponding to the breakpoints

This calculation is repeated for each pollutant, and the highest resulting index becomes the AQI for that time and location.

2.4.3 Interpretation of AQI Values and Health Implications

Once calculated, AQI values are placed into descriptive categories that indicate the associated level of health concern. These categories help people, especially those with health issues, understand whether it is safe to be outside or not.

Table 2.1: Interpretation of AQI Values

AQI value	**Category**	**Color**	**Health Implications**
0 -50	Good	Green	Air quality is satisfactory, posing little or no risk.

51-100	Moderate	Yellow	Air is acceptable; but some pollution may affect very sensitive individuals.
101-150	Unhealthy for sensitive groups	Orange	Older adults, children, and people with lung or heart conditions may be affected.
151-200	Unhealthy	Red	Everyone may begin to feel effects; sensitive groups more seriously affected.
201-300	Very unhealthy	Purple	Health warnings issued; emergency conditions may arise.
301-500	Hazardous	Maroon	Serious health effects; the entire population is likely to be affected.

(Source: USEPA, 2018)

In the context of a university environment like the University of Benin, even moderate levels of pollution (AQI 51–100) can affect students with respiratory conditions like asthma. Monitoring AQI regularly helps campus authorities take preventive measures such as limiting outdoor activities, improving ventilation in classrooms, or adjusting generator use.

2.5 Environmental Guidelines and Regulatory Standards

2.5.1 World Health Organization (WHO) Standards

The World Health Organization (WHO), provides global guidelines on environmental pollutants to protect human health. These standards are science-based and are often adopted by various countries around the world. Air quality guidelines for WHO, were updated in 2021 to reflect the latest scientific understanding of how pollutants like $PM_{2.5}$, PM_{10}, O_3, and CO affect human health. Some of the WHO recommended limits include:

i. $PM_{2.5}$: 15 µg/m^3 (24-hour mean)

ii. PM_{10}: 45 µg/m^3 (24-hour mean)

iii. O_3: 10 ppm (8-hour mean)

iv. CO: 10 ppm (8-hour mean)

For noise, WHO considers 55 dB(A) as the maximum allowable daytime outdoor level to avoid health risks like sleep disturbance and cardiovascular issues, while 40 dB(A) is preferred for nighttime (WHO, 2021).

2.5.2 National Environmental Standards and Regulations Enforcement Agency (NESREA)

In Nigeria, the National Environmental Standards and Regulations Enforcement Agency (NESREA) is the body responsible for setting and enforcing environmental quality standards. NESREA guidelines are tailored to local conditions, addressing both urban and industrial pollution sources. For air pollutants, NESREA prescribes the following 24-hour limits:

i. $PM_{2.5}$: 25 µg/m^3

ii. PM_{10}: 50 µg/m^3

iii. CO: 10 ppm

iv. O_3: 10 ppm

2.5.3 Federal Ministry of Environment (FMEnv) Guidelines

The Federal Ministry of Environment (FMEnv) plays a bigger role in policy and regulation in Nigeria. While NESREA enforces environmental laws, FMEnv provides national frameworks, policy direction, and detailed environmental guidelines for states, LGAs, and institutions.

FMEnv's air quality targets are often in line with those from NESREA and WHO, with specific focus on pollutants from traffic, industry, open waste burning, and generators, which are all relevant to a campus setting. They also support regular Environmental Impact Assessments (EIAs) for institutions undertaking construction or expansion projects (FMEnv, 2013).

2.5.4 United States Environmental Protection Agency (US EPA)

The US Environmental Protection Agency (EPA) serves as a global reference for air quality management. Their National Ambient Air Quality Standards (NAAQS) set strict limits for major air pollutants to protect both human health and the environment. The EPA's 24-hour standards include:

i. $PM_{2.5}$: 35 µg/m^3

ii. PM_{10}: 150 µg/m^3

iii. CO: 9 ppm (8-hour mean)

iv. O_3: 0.07 ppm (8-hour mean)

For noise, the US does not have federal applicable noise limits, but the EPA recommends 55 dB(A) for outdoor day-time exposure and 45 dB(A) for indoor residential settings (USEPA, 2022)

2.6 Review of related works

Environmental quality is an increasingly important concern, especially in academic environments where the health and productivity of students and staff can be directly affected by air and noise pollution. Over the years, researchers have investigated these issues in different parts of the world, including Nigeria, using various methods to monitor pollutants and assess their impact. This section takes a closer look at previous studies that have focused on air quality and noise levels in university settings, high lighting what has been done, where gaps exist, and how this current project fits into the broader conversation.

In Nigeria, air pollution on university campuses has been the subject of a number of studies, particularly in relation to particulate matter and gaseous emissions. Raimi et al. (2021) carried out a study on both indoor and outdoor air quality in a Nigerian university. They measured pollutants like $PM_{2.5}$, PM_{10}, and carbon monoxide (CO), and found out that these pollutants, especially the fine particles, often exceeded recommended limits, especially when activity on campus was at its peak. They made use of a portable sensors and analyzed the data using the Air Quality Index (AQI), which helped interpret how dangerous air quality levels were.

Similarly, Adegoke et al. (2013) studied air quality around student hostels at Obafemi Awolowo University. Their findings showed high levels of CO and $PM_{10,}$ mostly linked to frequent use of generators and the constant movement of vehicles. They also pointed out the health risks associated with this kind of exposure, especially for students who spend long periods in and around these areas. While such studies shed light on air pollution in Nigerian universities, it is notable that there is still very limited data available for the University of Benin.

Noise pollution is another important but sometimes overlooked issue in university environments. Olusanya et al. (2015) assessed noise levels in a few Nigerian universities and found that sound levels in both academic and residential areas often went above safe limits set by World Health Organization (WHO) and Nigeria's Regulatory body, NESREA. Common sources included traffic, generators, and student gatherings. In a broader context, Babisch (2005) examined the long term health effects of noise exposure in European communities. He found a link between chronic noise and serious health problems like high blood pressure and heart disease, and also noted that high noise levels can affect concentration and learning, which is very much relevant in a university setting.

Looking beyond Nigeria, several international studies offer useful insights that can help guide local research. For instance, Kim and Han (2018) studied air quality in South Korean university classrooms. Their findings revealed that air quality worsened as classrooms filled with students, particularly with rising levels of CO_2 and $PM_{2.5}$. They recommended better ventilation systems and stronger air quality policies in schools. In India, Mohapatra et al. (2020) used GIS and AQI/NNI tools to study noise pollution on university campuses. Their work led to suggestions like planting more trees and limiting vehicle access to academic areas to reduce pollution. These international examples provide useful strategies that can be adopted for campuses like the University of Benin.

Interestingly, while many studies look at air and noise pollution separately, only few have tried to assess both together. Ugbebor and Erhabor (2022) did so in their research on school and roadside environments in Warri, Nigeria. They measured particulate matter and noise levels at the same time, which gave them a broader picture of the risks people were facing. Similarly, Chithra and Nagendra (2016) studied air and noise pollution near schools in India and discovered that both pollutants were regularly above acceptable limits, particularly during school days. Their research highlighted the importance of looking at both issues together rather than separately. More recently, Raimi et al. (2023) combined the use of AQI and NNI to evaluate environmental conditions on Nigerian campuses. Their work showed that using both tools helps to understand the impact of pollution better and it provides clearer guidance for improving campus environments

Despite these great efforts there are still gaps in existing research. For example, there is hardly any published data on the environmental quality of the University of Benin, Ugbowo campus. Most studies focus on other schools or broader urban areas. Also, very few studies attempt to assess both air and noise pollution together using standard tools such as AQI and NNI. Without this dual approach, we miss the chance to understand full environmental picture,

This study is designed to help close together those gaps. It focuses specifically on the University of Benin, Ugbowo campus, where both human and vehicular activities are high. This research will collect data on the criteria air pollutants and also measure noise levels in different areas of the campus. By applying both AQI and NNI, this study aims to provide a reliable and clear picture of the air and noise conditions on campus. In doing so, it hopes to raise awareness, support implementation of policies against air and noise pollution, and more sustainable practices within the university environment.

CHAPTER THREE

METHODOLOGY

3.1 Description of the Study Area

This research took place at the University of Benin, Ugbowo Campus, in Benin City, Edo State, Nigeria. The campus is located around latitude 6.3949° N and longitude 5.6215° E and is made up of various zones, including academic buildings, hostels, commercial centers, green areas, and administrative blocks. These different areas have varying levels of human and vehicular activity, which makes the campus a suitable place to study air and noise pollution.

Benin City has a tropical climate with two main seasons, the wet season from April to October and the dry season from November to March. The average temperature ranges between 26°C and 32°C, and humidity often stays between 60% and 90%. These weather conditions affect how pollutants spread in the air or how sound travels. To map the study area, ArcGIS pro was used, a geographic information system tool. Sampling locations were identified and recorded using GPS-enabled smartphones, and the coordinates were used to create maps that show how air and noise pollution vary across the campus.

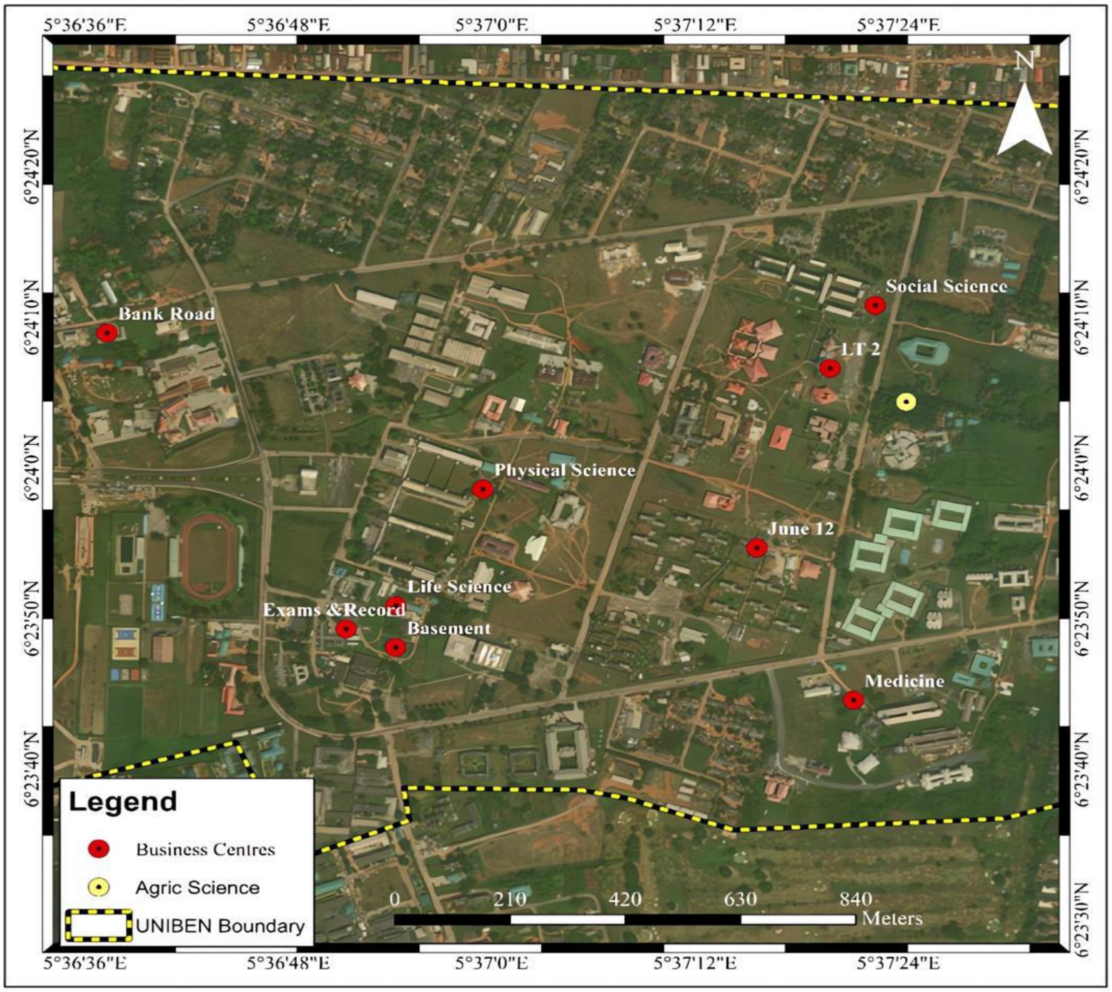

Figure 3.1: Topographical location of the University of Benin

3.2 Research Design

This study uses a descriptive study design, therefore the air quality and noise level data were collected simultaneously at selected points within the campus. Measurements were taken both in the morning and evening to observe temporal variations in air and noise pollution.

To make sure every major area was included, stratified random sampling method was used. The campus was divided into five categories based on how they are used:

i. Academic areas

ii. Residential areas

iii. High-traffic zones

iv. Commercial spots

v. Quiet or green areas

3.3 Selection of Sampling Locations

Sampling locations were chosen to represent the various environments within the campus. Based on use and activities done, the following are the selected areas;

i. Residential areas which may include hostels, staff quarters and so on

ii. Academic areas which may include faculties and so on

iii. High-traffic zones which may include car parks, main gate and so on

iv. Commercial spots which may include buka, physical complex and so on

v. Quiet or green area which may include sports complex and so on

The GPS location of each spot was noted using a smartphone and then the data were uploaded into ArcGIS pro for mapping and analysis.

3.4 Materials and Equipment

The air quality monitor and ozone meter are devices that measure $PM_{2.5}$, PM_{10}, CO and O_3. It has a real-time digital display, and stores data that can be analyzed later. It is portable and ideal for outdoor measurements.

As for noise, the digital sound level meter was used. This instrument helped check how noisy each location was. It showed sound levels in decibels dB(A) and could detect quick changes in noise.

Other materials that were used were GPS-enabled smartphones, for recording coordinates, ArcGIS pro software, to create maps and visual results, field notebooks, and extra batteries

Figure 3.2Air quality monitor

Figure 3.3 Ozone meter

Figure 3.4Sound level meter

3.5 Parameters that were measured

The following are the parameters that were measured:

For air pollution we have;

i. $PM_{2.5}$

ii. PM_{10}

iii. CO (Carbon monoxide)

iv. O_3 (Ozone)

For noise pollution we have;

i. Sound levels in decibels

Other parameter that was measured is;

i. GPS location

3.6 Data Collection Procedure

At each site, the air quality monitor and ozone meter was used to measure the air quality data gotten which was recorded after 5 minutes at each point which was then averaged. The sound level meter measured three readings which were taken and averaged. This was done two times daily. Afterwards, coordinates of each location were recorded, and all data was entered into ArcGIS pro for mapping.

3.7 Data Analysis

The recorded data were analyzed using Microsoft excel, AirNow AQI calculator and ArcGIS pro software. Descriptive statistics were calculated for each air quality and noise level parameters.

For Air Quality Index (AQI):

The AQI helped simplify complex pollution data. Using the EPA's method, each pollutant's value were turned into a score (called a sub-index). The highest sub-index will be used as the final AQI for that location.

AQI = maximum value of $PM_{2.5}$, PM_{10}, CO, O_3 sub-index

All measured values were compared with WHO and NESREA permissible limits to determine compliance with standards.

For GIS and Statistics:

In ArcGIS pro, interpolation method is used to visualize pollution patterns. Heatmaps were created to show high or low pollution areas. Statistical analysis like averages were taken and comparisons to standards was done using Excel.

3.8 Quality Control

To ensure the results are reliable:

i. The air quality monitor and ozone meter was calibrated before starting.
ii. Each reading was taken thrice to check for consistency.
iii. Data was not collected during extreme weather.
iv. All GPS readings were cross-checked.

3.9 Ethical Considerations

Permission was gotten from the right authorities, though many were not granted. No personal data was collected, and there was no disturbance to students or staff.

3.10 Limitations

i. Limited access to certain parts of the campus
ii. Weather changes affecting measurements
iii. Short data collection period
iv. Late arrival of instruments

CHAPTER FOUR

RESULTS AND ANALYSIS OF RESULTS

4.0 Introduction

This chapter analyzes and discusses the results of air quality and noise levels conducted at the University of Benin, Ugbowo Campus. Measurements were obtained using an air quality monitor, capable of simultaneously recording $PM_{2.5}$, PM_{10}, CO, and an ozone meter, and environmental noise levels were captured in decibels at the same sites during morning and evening sessions to observe temporal fluctuations.

The study focuses on assessing air pollution and noise exposure across different campus areas. Observed values were evaluated against WHO and NESREA standards. Additionally, the Air Quality Index (AQI) was calculated using U.S. EPA (2016) guidelines to classify air quality into recognized health-based categories.

4.1 WHO and NESREA standards for comparison

Table 4.1 below presents the permissible limits for major air pollutants and noise levels based on WHO and NESREA guidelines. These limits were used to assess whether measured concentrations fall within acceptable ranges.

Table 4.1 WHO and NESREA standards and interpretation

PARAMETER	WHO STANDARD	NESREA STANDARD	AVERAGING TIME	INTERPRETATION
$PM_{2.5}$	15 µg/m³	25 µg/m³	24-hour mean	Within safe limits

PM_{10}	45 µg/m³	50 µg/m³	24-hour mean	Within safe limits
CO	10 ppm	10 ppm	8-hour mean	Within safe limits
O_3	0.051 ppm	0.12 ppm	8-hour mean	Within safe limits
Noise levels	55dB(A)	55dB(A)	55dB(A)	Slightly exceeds at campus gates

The recorded data across the University of Benin generally fell within these recommended limits, though slight noise exceedances were observed in areas of high human and vehicular activity.

4.2 Table of values

The table below shows the AQI values and values of each pollutants alongside the sample locations

Table 4. 1: Table of values

SAMPLE LOCATION	TIME	PM_{10} (ug/m3)	$PM_{2.5}$ (ug/m3)	CO (ppm)	O_3 (ppm)	NOISE (decibels)	AQI VALUES
FACULTY OF ENGINEERING	MORNING	45	39	0	0.001	65.37	37
	EVENING	45	39	0	0.001	62.0	37
PHYSICAL SCIENCE	MORNING	44	38	0	0.02	66.8	36
	EVENING	42	36	0	0.02	63.5	34
FESTUS IYAYI HALL	MORNING	44	38	0	0.02	66.0	36
	EVENING	44	38	0	0.02	61.7	36
FACULTY OF SCIENCE LABORATORY AND TECHNOLOGY	MORNING	44	38	0	0.01	60.7	36
	EVENING	43	37	0	0.01	57.7	35
FACULTY OF MANAGEMENT SCIENCE	MORNIG	43	37	0	0.03	83.4	35
	EVENING	43	37	0	0.02	79.2	35
QUEEN IDIA HOSTEL (HALL 1)	MORNING	45	39	0	0.02	63.0	37
	EVENING	44	38	0	0.02	66.0	36
MADAM TINUBU HOSTEL (HALL 2)	MORNING	43	37	0	0.02	63.0	35
	EVENING	42	36	0	0.02	66.2	34
MALLAM AMINU KANO HOSTEL (HALL 3)	MORNING	44	38	0	0.02	66.4	36
	EVENING	43	37	0	0.02	69.7	35
JUNE 12	MORNING	49	43	0	0.02	74.0	40
	EVENING	48	42	1	0.02	78.1	40
AKANU IBIAM HOSTEL (HALL 4)	MORNING	45	39	0	0.03	75.1	37
	EVENING	44	38	0	0.03	78.9	36
FACULTY OF LAW	MORNING	44	39	0	0.02	72.1	37
	EVENING	42	37	1	0.02	68.5	35
FACULTY OF AGRICULTURE	MORNING	46	40	0	0.02	59.4	37
	EVENING	44	36	0	0.02	55.8	34
FACULTY OF SOCIAL SCIENCE	MORNING	46	40	0	0.02	76.8	37
	EVENING	46	40	0	0.02	72.2	37
EKOSODIN BACK GATE	MORNING	54	48	3	0.02	81.0	55
	EVENING	56	50	1	0.02	86.7	46
MAINGATE	MORNING	56	50	0	0.03	66.6	46
	EVENING	58	52	0	0.03	71.6	47

FACULTY OF EDUCATION	MORNING	43	38	0	0.03	65.6	36
	EVENING	41	36	0	0.02	61.7	34
SMALL GATE	MORNING	47	42	0	0.07	66.5	39
	EVENING	45	40	0	0.07	71.2	37
WEMA BANK /KEYSTONE BANK	MORNING	42	36	0	0.02	61.2	34
	EVENING	40	34	0	0.01	57.8	32
MAINGATE SHOPPING COMPLEX	MORNING	43	37	0	0.02	60.5	35
	EVENING	43	37	0	0.02	62.1	35
SPORTS COMPLEX	MORNING	41	36	0	0.02	58.1	34
	EVENING	41	36	0	0.02	54.9	34
UNITY MICROFINANCE BANK	MORNING	38	33	0	0.02	63.5	32
	EVENING	36	31	1	0.01	59.4	34
BURSARY	MORNING	41	36	0	0.02	64.3	34
	EVENING	39	34	0	0.01	60.1	32
EXAMS AND RECORD	MORNING	42	37	0	0.02	67.6	35
	EVENING	40	35	0	0.02	63.2	33
HOME AND AWAY RESTAURANT	MORNING	40	35	0	0.02	58.0	33
	EVENING	40	35	1	0.02	62.0	37
COLLEGE OF POST GRADUATE STUDIES	MORNING	41	36	0	0.02	58.7	34
	EVENING	39	34	0	0.02	54.8	32
STUDENT AFFAIRS/ SECRETARIAT	MORNING	39	34	0	0.02	67.0	32
	EVENING	37	32	0	0.02	62.6	31
FACULTY OF BIOCHEMISTRY	MORNIG	38	33	0	0.01	65.1	32
	EVENING	38	33	0	0.01	61.2	32
OLD PHARMACY / FACULTY OF VETERINARY MEDICINE	MORNING	39	34	0	0.02	76.5	32
	EVENING	39	34	0	0.02	72.0	32
ANATOMY BACKGATE	MORNING	40	35	0	0.03	76.5	33
	EVENING	42	37	0	0.02	82.0	35

CLINICAL HOSTEL	MORNING	39	34	0	0.02	62.0	32
	EVENING	38	32	0	0.02	65.1	31
JOHN HARRIS LIBRARY	MORNING	39	34	0	0.02	60.7	32
	EVENING	37	32	0	0.02	56.1	31
LIBRARY EXTENSION	MORNING	42	36	0	0.03	60.5	34
	EVENING	40	34	0	0.02	58.8	32
UNIBEN MICROFINANCE BANK	MORNING	38	33	0	0.03	58.1	32
	EVENING	36	31	1	0.01	54.6	36
HELENA RESTAURANT	MORNING	38	33	0	0.02	67.2	32
	EVENING	38	33	0	0.02	71.6	32
NDDC HOSTEL	MORNING	39	34	0	0.02	64.6	32
	EVENING	37	33	0	0.02	67.8	32
BUKA	MORNING	40	35	0	0.03	58.1	33
	EVENING	38	33	0	0.03	61.0	32
JSQ (JUNIOR STAFF QUARTERS)	MORNING	39	34	0	0.02	63.8	32
	EVENING	38	33	0	0.02	67.0	32
FACULTY OF BASIC MEDICAL SCIENCES	MORNING	41	36	0	0.01	65.9	34
	EVENING	39	34	0	0.01	62.3	32
SCHOOL OF DENTISTRY	MORNING	39	34	0	0.02	54.2	32
	EVENING	37	32	0	0.01	51.2	31
COLLEGE OF MEDICAL SCIENCES	MORNING	35	30	0	0.02	64.8	26
	EVENING	31	27	2	0.01	55.1	28
HALL 5	MORNING	38	33	0	0.02	62.5	32
	EVENING	36	32	0	0.02	65.6	31
HALL 6	MORNING	33	28	0	0.02	54.5	29
	EVENING	31	26	1	0.02	57.6	31
POST GRADUATE HOSTEL (HALL 7)	MORNING	31	30	0	0.02	55.4	26
	EVENING	29	28	1	0.02	58.2	28
ERASTUS ABIMBOLA HOSTEL	MORNING	36	31	0	0.02	61.5	31
	EVENING	35	30	0	0.02	64.6	30
CERHI COMPLEX	MORNING	48	43	0	0.02	62.6	40

	EVENING	46	41	0	0.02	59.2	38

4.3 Particulate Matter ($PM_{2.5}$ and PM_{10})

Particulate matter concentrations varied across the campus depending on traffic intensity, human activity, and location. The lowest $PM_{2.5}$ level (12 µg/m³) was recorded at halls 6 and 7 during evening hours, while the highest (28 µg/m³) occurred at ekosodin back gate in the morning. This indicates that $PM_{2.5}$ concentrations are more influenced by traffic and generator emissions than the type of campus facility.

For PM_{10}, a similar pattern was observed, ranging from 20 µg/m³ at the college of medical sciences to 40 µg/m³ at ekosodin back gate. Morning readings were slightly higher than evening measurements, likely due to peak traffic and early-hour combustion activities. Areas with lower human activity and abundant vegetation, such as academic and residential zones, recorded lower particulate levels, reflecting effective pollutant dispersion.

4.3.1 $PM_{2.5}$ and PM_{10} Heat maps

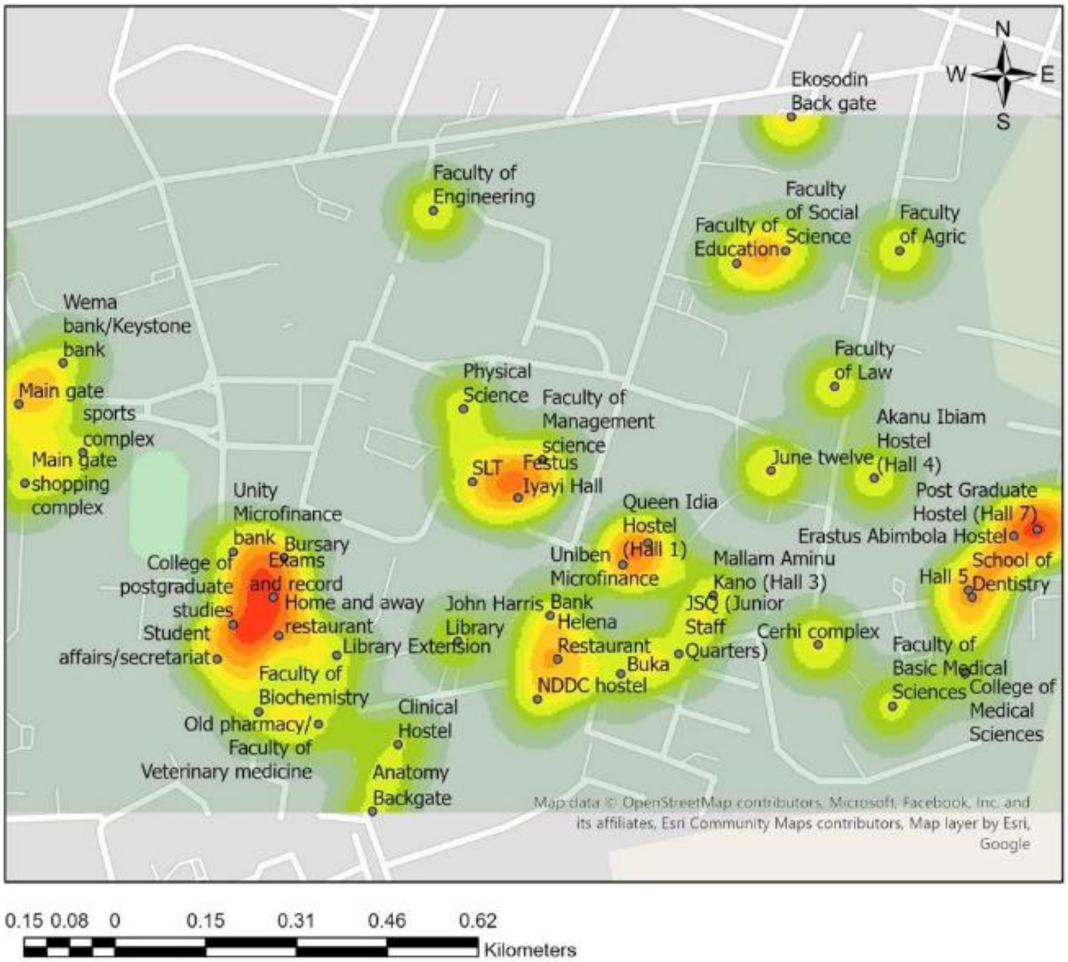

Figure 4.1: Heat map of $PM_{2.5}$ values across campus

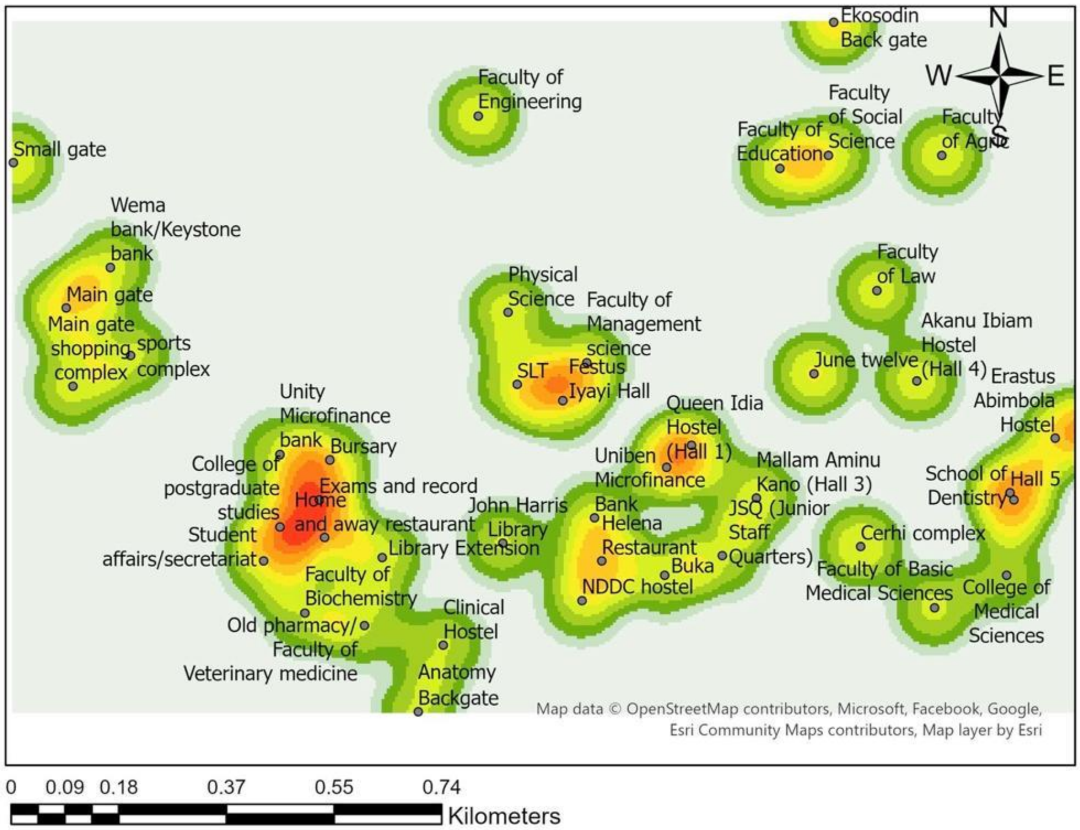

Figure 4.2: Heat map of PM10 values across campus

The heat maps for both $PM_{2.5}$ and PM_{10} showed red to orange patches concentrated around the main gate, ekosodin back gate, and nearby commercial areas, indicating moderate accumulation of particulate matter due to vehicle emissions and dust resuspension.

Green zones dominated the inner academic areas and hostels, showing lower pollution and better air circulation. All values remained below both WHO and NESREA standards, indicating safe exposure levels across the campus.

AQI values for particulate matter mostly fell within the good to moderate range, with the highest AQI of 55 at ekosodin back gate, nearing the "Unhealthy for Sensitive Groups" category (AirNow, 2023). The lowest AQI values (26–31) were found at the college of medical sciences and halls 6 & 7, indicating good air quality.

4.4 Carbon Monoxide (CO)

CO concentrations followed trends similar to particulate matter, reflecting areas affected by combustion sources. The lowest concentration, 0 ppm, while the highest, 3 ppm, was measured at ekosodin back gate in the morning.

Elevated CO levels occurred near gates, where traffic congestion is prevalent. In quieter academic and medical areas, CO levels were lowest.

4.4.1 Carbon Monoxide Heatmaps

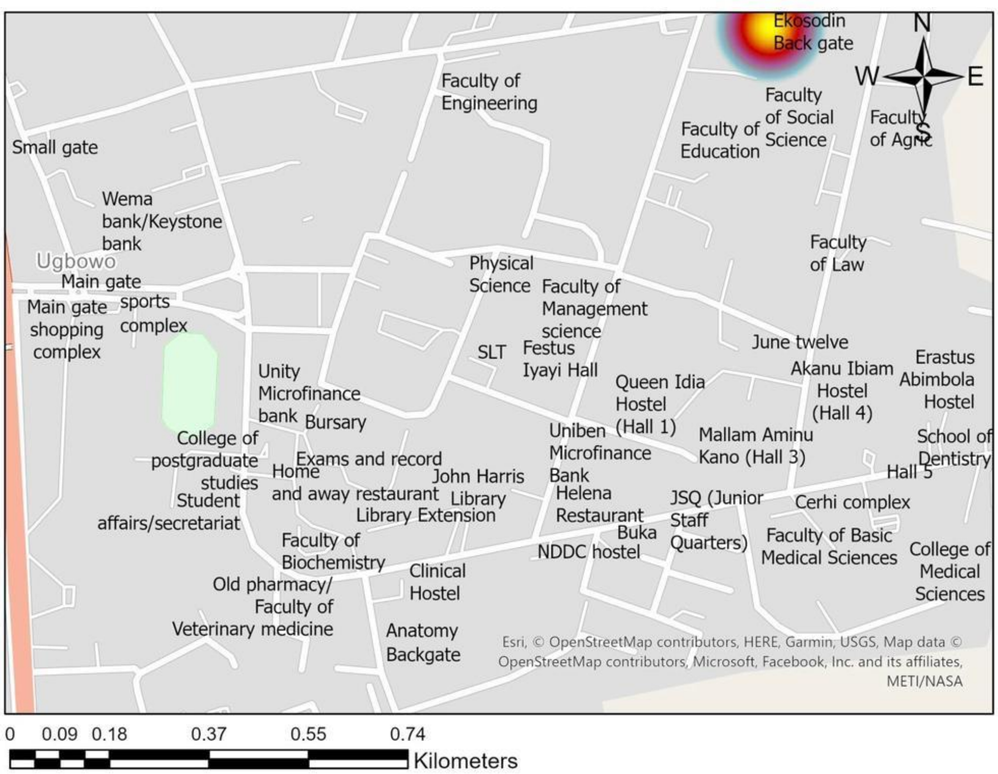

Figure 4.3: Heat map of CO values across campus

The CO heat map revealed hotspots at ekosodin back gate, showing the adverse effect of vehicular exhaust. Inner campus regions such as lecture halls and hostels appeared as clear, reflecting low exposure. All CO concentrations remained below the WHO and NESREA permissible limits, signifying minimal health risk except for mild irritation to sensitive individuals during peak hours.

Although AQI values for CO ranged from 0 ppm to 3 ppm, all measurements were below the WHO 8-hour limit, suggesting minimal effect to health. However, sensitive populations may experience mild effects during peak traffic periods, highlighting the need for traffic and generator regulation (EPA, 2016).

4.4 Ozone (O_3)

Ozone concentrations were consistently low throughout the campus. The lowest level, 0.01 ppm, was recorded at college of medical sciences, while the highest (0.07 ppm) was found at ekosodin back gate.

4.4.1 Ozone Heatmaps

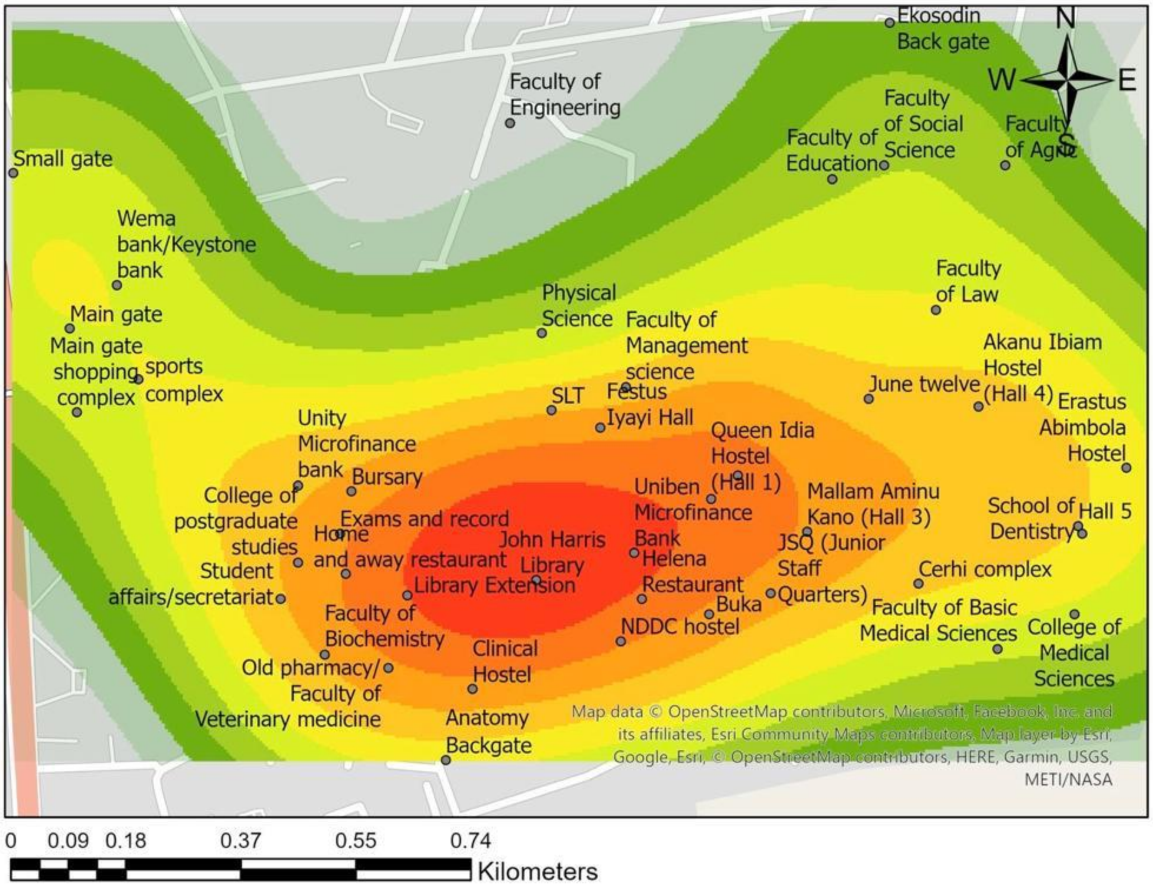

Figure 4.4: Heat map of O_3 values across campus

A slight increase in ozone levels occurred near campus gates and traffic corridors, most likely caused by emission from vehicles and generators. All measurements were below the WHO guideline, indicating minimal health risk. Residential areas and vegetation had lower O_3 levels.

4.5 Noise Levels

Noise levels varied depending on location. The quietest areas were halls 6 and 7 and the college of medical sciences, with levels ranging from 40–45 dB(A). The highest noise readings, however, occurred at the main gate with 58 dB(A) and ekosodin back gate with 60 dB(A), exceeding the WHO daytime limit of 55 dB(A).

High noise zones corresponded to heavy traffic, generator use, and commercial activities. Academic and residential areas experienced lower noise due to vegetation, distance from noise sources, and limited generator operations. These patterns are consistent with studies on Nigerian university campuses (Akinbode et al., 2019; Owoade et al., 2020).

4.6 AQI Heat Map Analysis

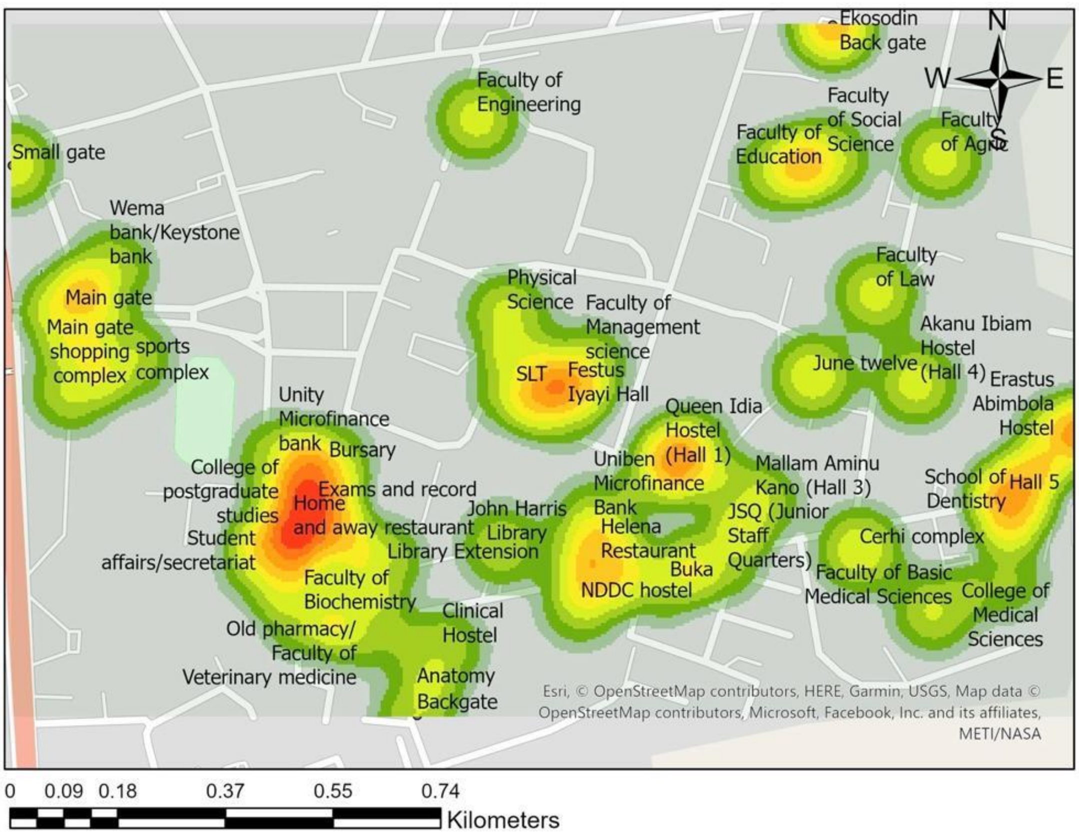

Figure 4.5: Heat map of AQI values across campus

The heat map illustrates how AQI varies between high-activity areas and quieter zones. ekosodin back gate, with an AQI of 55, has the highest concentration point. Main gate and small gate also showed increased AQI due to traffic and generator activity. College of medical sciences, halls 6 and 7, and clinical hostel had the lowest AQI of 26–31, highlighting the benefits of open space and vegetation.

Heat map visualization depicts red/orange hotspots at gates and traffic zones, yellow/green moderate zones at academic blocks, and light green low-pollution areas at vegetated, central campus locations. This pattern emphasizes the importance of environmental zoning, buffer zones, and generator placement (Osibanjo & Ogunshe, 2018; Anake et al., 2020).

4.7 Discussion of Results

The results of the study indicate that overall air quality at the University of Benin campus is acceptable, with levels of $PM_{2.5}$, PM_{10}, carbon monoxide, and ozone generally falling within good to moderate ranges. An increase in pollutant concentrations were observed mainly around campus gates and commercial areas, identifying these as hotspots likely influenced by traffic and human activity.

Noise, however, was found to be a more significant concern, particularly in areas of high activity, suggesting it has a greater impact on comfort and wellbeing than air pollution. Conversely, academic and residential sections of the campus showed lower pollution and noise levels.

These findings emphasize the importance of coordinated measures such as traffic regulation, strategic generator placement, increased green spaces, and ongoing environmental monitoring to sustain air quality and comfort across the campus.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter summarizes the results of the study on air quality and noise levels at the University of Benin, Ugbowo Campus, draws conclusions, and provides recommendations. The findings are compared with relevant national and international standards to assess environmental compliance and potential health impacts.

5.1 Conclusion

The assessment of air quality and noise at the University of Benin campus indicates that overall conditions are generally satisfactory. $PM_{2.5}$, PM_{10}, carbon monoxide, and ozone levels were mostly within good to moderate AQI ranges. Higher pollutant concentrations were observed near the ekosodin back gate, main gate, and small gate due to heavy traffic, generator use, and pedestrian activity, while areas such as the college of medical sciences, halls 6 and 7, and the clinical hostel recorded lower levels, benefiting from reduced activity and the presence of vegetation.

Carbon monoxide exhibited a similar pattern, with increased values in high-traffic areas but remaining below WHO and NESREA limits. Ozone levels were generally low across the campus, with minor increases near campus gates. Noise measurements, however, revealed that high-traffic and commercial areas often exceeded the WHO daytime limit, whereas academic and residential zones remained within acceptable levels.

In conclusion, while overall air quality on campus is acceptable, localized pollution near gates and commercial zones may pose occasional risks, particularly to sensitive individuals. Noise pollution emerges as the more significant concern in high-activity areas. Vegetation and campus planning effectively mitigate both air and noise exposure, highlighting the need for more green areas, strategic generator placement, traffic management, and continuous monitoring to maintain a safe and comfortable environment for all campus users.

5.2 Recommendations

Improving air and noise quality on the University of Benin campus requires practical solutions targeting key sources of pollution. Traffic management should limit vehicles in academic zones, create pedestrian paths, and enforce car-free areas, while generators should be properly maintained, and used minimally during peak hours. Planting trees and shrubs along roads and near gates can help reduce both air pollutants and noise levels.

In addition, awareness campaigns can educate students and staff about pollution sources and mitigation strategies, while routine monitoring can identify hotspots and track improvements. Enforcing policies on waste burning, construction emissions, and generator placement further reduces environmental risks. Future studies should consider seasonal changes and additional pollutants such as nitrogen dioxide, sulfur dioxide, and volatile organic compounds to provide a more complete assessment.

Together, these measures will help maintain and improve air and noise quality, ensuring a healthier and more comfortable campus.

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