ANALYSIS OF ATMOSPHERIC PARAMETERS WITHIN UNIVERSITY OF BENIN (UNIBEN) USING PURPLEAIR SENSOR

BY

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LSC2007302

(BIOLOGICAL SCIENCE TECHNIQUES)

DEPARTMENT OF SCIENCE LABORATORY TECHNOLOGY

FACILTY OF LIFE SCIENCES

UNIVERSITY OF BENIN

BENIN CITY

NOVEMBER, 2025

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A PROJECT WORK SUBMITTED TO THE DEPARTMENT OF SCIENCE LABORATORY TECHNOLOGY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, EDO STATE, NIGERIA. IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR'S DEGREE (B.Sc.) IN SCIENCE LABORATORY TECHNOLOGY.

NOVEMBER, 2025

CETIFICATION

This is to certify that this project work titled **"Analysis of Atmospheric Parameters within University of Benin (UNIBEN) using Purpleair Sensor"** Was carried out by **Angel Osarugue IDAHOSA** with Matriculation Number **LSC2007302**, of the Department of Science Laboratory Technology (Biological Science Techniques), Faculty of Life Sciences, Benin City, Edo State, Nigeria.

Dr. A. ORUPKE **(Project Supervisor)**	Date
Dr. P.O ALONGE **(Project Coordinator)**	Date
Prof. J.O. OSARUMWENSE **(Head of Department)**	Date
External Supervisor	Date

DEDICATION

With deepest gratitude, I dedicate this work to Almighty God, whose boundless strength, grace, patience, and provision have sustained me throughout this journey. He has been my guide from the beginning to the end of this journey.

ACKNOWLEDGEMENT

I give thanks to Almighty God for his endless grace, love, wisdom and strength that enabled me to complete this work successfully. I am indeed grateful to Almighty God for his provision throughout the period of my academic journey in the University of Benin.

My profound gratitude also goes to my competent Supervisor, Dr. Alex Orukpe for his nonstop support and attention despite his busy schedule to go through my work leading to the emergence of this report. I am grateful to my parents and siblings for their love and support and to everyone who assisted me in the course of this research. A hearty thanks to myself for the consistency and courage to complete this work with all the relevant pieces of information.

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LIST OF ABBREVIATIONS

AQI: Air Quality Index

BDPA: Bendel Development and Property Authority

CSV: Coma Separated Values

^oC: Degree Centigrade

^oF: Degree Fahrenheit

^oK: Degree Kelvin

%: Percentage

$PM_{2.5}$ µm: Particulate Matter with a Diameter of 2.5micrometers

$PM_{10.0}$ µm: Particulate Matter with a Diameter of 10.0 micrometers

RH: Relative Humidity

UNIBEN: University of Benin

Mg/m^2: The number of micrograms of a substance present per cubic meter of air

WHO: World Health Organization

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STUDENT'S THESIS

AUTHOR'S STATEMENT

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ABSTRACT

This study Analyzed Atmospheric Parameters, $PM_{2.5}$ concentration, temperature, and relative humidity within the University of Benin (UNIBEN) using a PurpleAir sensor between January and March 2025. The research aimed to assess the air quality and evaluate the microclimatic conditions affecting the campus environment. The PurpleAir sensor was installed at the Space-Earth Environment Research Laboratory to record real-time data at two-minute intervals. Data were processed and analyzed using Microsoft Excel for descriptive statistics, correlation, and graphical presentation. The results revealed that $PM_{2.5}$ concentrations ranged between 58 $\mu g/m^3$ and 202 $\mu g/m^3$, exceeding the World Health Organization (WHO) recommended limit of 25 $\mu g/m^3$, indicating consistently unhealthy air quality. Temperature values ranged from 20°C to 33°C, typical of the tropical dry and early wet seasons, while relative humidity varied between 32% and 100%. Analysis showed an inverse relationship between $PM_{2.5}$ and relative humidity, implying that drier air conditions intensified particulate pollution. The findings highlight the need for continuous air monitoring and pollution control measures within the university. This study demonstrates the effectiveness of low-cost IoT-based sensors in generating reliable, real-time atmospheric data for environmental management and campus sustainability.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF STUDY

Clean air is essential for life and well-being. To maintain good health, we need to constantly breathe in clean and safe air. However, the air around us often contains different types and sizes of particulate matter, and the amount of these particles changes depending on the time and location. Unfortunately, human activities which include industrialization, urban growth, population growth and altering consumption arrangements, have a negative impact on the air quality (Zhang *et al.*, 2022).

1.1.1 What is PM2.5?

PM2.5 is particulate matter with a diameter of 2.5 micrometers or less. Fine particles are about 30 times thinner than the thickness of a human hair and can only be seen with an electron microscope. PM2.5 is emitted from numerous sources, including vehicle emissions, industrial processes, residential combustion (wood or coal burning), and natural sources such as wildfires and dust storms (Tiwari *et al.*, 2024). These particulate matters are of various sizes: fine particles in the air ≤ 1 µm are classified as PM1.0; fine particles in the air ≤ 2.5 µm are classified as PM2.5; fine particles in the air ≤ 10 µm are classified as PM10.0, in all, PM2.5 is the most dangerous size to humans because it impairs respiratory mechanism

(Orukpe *et al*., 2022). Exposure to PM2.5 has been linked to a wide range of serious health problems. These include respiratory diseases (such as asthma, bronchitis, and chronic obstructive pulmonary disease), cardiovascular diseases (such as heart attacks, strokes), and even premature death (Orukpe *et al*., 2022). World Health Organization (WHO) states that PM2.5 is one of the most harmful air contaminants through its ability to traverse the lung barrier and reach the blood system (WHO, 2021). Long-term exposures also lead to the development of diseases such as lung malignancy and have been associated with improper pulmonary development in children. Vulnerable populations such as children, the elderly, and individuals with pre-existing health conditions are most vulnerable (Pope and Dockery, 2006).

1.1.2 What is Temperature?

Temperature is the physical quantity that determines the degree of hotness or coldness of an object or environment. Temperature is an indication of the average kinetic energy of the molecules in an object that is, the velocity with which molecules or atoms are moving. The larger the motion the molecules are in, the larger the temperature. Temperature is measured by the help of thermometers and is indicated in terms of scale units such as degrees centigrade (°C), Fahrenheit (F), or kelvin (K) (Wilson, 2024).

1.1.3. Relevance of Temperature Monitoring in UNIBEN Using PurpleAir Sensor

Temperature monitoring within academic environments like the University of Benin (UNIBEN) is critical for understanding how microclimatic conditions affect health, learning, and infrastructure. With the deployment of low-cost air quality monitoring devices such as the PurpleAir sensor, it is now possible to collect high-resolution temperature and particulate matter data in real time. While PurpleAir sensors are primarily used to measure particulate pollution (especially PM2.5), they also record environmental temperature, offering valuable insight into campus microclimate patterns (Makun, 2019).

The measurement of temperature is also significant because students and staff spend long hours within the campus environment, and both excessive heat can impair cognitive function, reduce productivity, and present heat stress or dehydration risks Identification of temperature patterns across lecture halls, hostels, and open areas enables the university to envision interventions such as tree planting, ventilation enhancement, and building energy consumption management (Akoh, , 2023).

Additionally, temperature monitoring plays a significant role in the university's climate adaptation and sustainability initiatives. As the effects of global warming increase, campuses such as UNIBEN face risks from heat waves and fluctuating thermal conditions. Ongoing monitoring offers crucial baseline data for crafting policies regarding energy-efficient infrastructure and planning for climate resilience. The PurpleAir sensor is particularly well-suited for this task, as it provides real-time data on ambient temperature and humidity in addition to measuring particulate matter (Venkatraman *et al*., 2021).

1.1.4 What is Relative Humidity?

Relative humidity (RH) is the proportion of water vapor held in the air as a percentage of air holding capacity at a certain temperature. Relative humidity is a significant environmental factor that affects comfort, human health, building stability, and indoor air quality. Measurement of relative humidity by real-time air sensors like the PurpleAir sensor at the University of Benin (UNIBEN) provides valuable data for evaluation and decision-making purposes (Ramis *et al*., 2012).

1.1.5 Relevance of Relative Humidity Monitoring in UNIBEN Using PurpleAir Sensors

Relative humidity (RH) is a critical atmospheric parameter that reflects the ratio of the existing water vapor content in the air to the amount of water vapor the air can hold at a given temperature by percentage. The measurement of relative humidity in the University of Benin (UNIBEN) is highly relevant since it has direct impacts on human comfort, indoor and outdoor air quality, and working of air quality sensors such as the PurpleAir sensor.

Relative humidity also plays significantly in the meteorological condition and health connection. Excessive humidity with the high ambient temperature increases thermal distress and even leads to heat stress, fatigue, and decreased learning or work effectiveness of students and staffs. Extremely low humidity, in contrast, triggers dehydration, respiratory irritation, and increased airborne transfer of diseases (Guarnieri *et al*., 2023). RH monitoring therefore allows the university to gain an enhanced understanding of microclimatic conditions affecting health and productivity across the campus.

In addition, relative humidity is closely related to indoor air quality and building performance. Most of the classrooms, libraries, and hostels in UNIBEN are ventilated naturally or with the aid of fan cooling. High RH in these facilities will lead to dampness, mold, and damage to teaching materials, while also contributing to discomfort among occupants. The real-time monitoring allows the university managers to implement measures such as improved ventilation design, insulation, or use of dehumidifiers wherever necessary.

The PurpleAir sensor, in addition to the measurement of particulate matter, also includes onboard relative humidity and temperature sensors (Couzo *et al*., 2024). It is therefore a handy device for the simultaneous monitoring of pollution and weather. By installing the PurpleAir sensor in UNIBEN, quality RH data can be generated to match $PM_{2.5}$ data for the simpler interpretation of pollution levels and overall atmospheric quality.

1.2 STATEMENT OF PROBLEM

Monitoring air quality is important in quantifying the environmental health but the majority of institutions like University of Benin(UNIBEN) do not have access to real-time, localized data on atmospheric conditions. Conventional monitoring methods are either not available, or costly which leaves knowledge gaps regarding pollution levels, temperature fluctuations, humidity and particulate matter (PM2.5) in the UNIBEN.

The purpose of this study is to analyze atmospheric parameters (PM2.5, temperature and relative humidity) within the University of Benin using a PurpleAir sensor.

Without such an analysis, health initiatives are hampered as the University community is not made aware of any possible air quality hazards. With the utilization of low-cost IoT-based sensor technology, this project offers a viable solution for real-time air quality monitoring in UNIBEN, for a healthier and more sustainable campus environment.

1.3 AIM OF STUDY

Examine Atmospheric Parameters within the University of Benin(UNIBEN) using a PurpleAir sensor

1.4. OBJECTIVES OF STUDY

- To analyze PM2.5 data within the said period (January, February and March 2025).
- To analyze temperature.
- To analyze Relative humidity

1.5 SIGNIFICANCE OF STUDY

Analyzing atmospheric parameters such as particulate matter (PM 2.5), temperature and relative humidity at University of Benin(UNIBEN) using PurpleAir sensor is important for the following reasons:

- To provide accurate data on environmental conditions on environmental conditions such as particulate matter (PM 2.5), temperature and relative humidity that are central elements in determining air quality and public health risk.
- This study shows the effectiveness of using low-cost sensors like PurpleAir to track atmospheric conditions, where atmospheric monitoring is made less complicated and more affordable to attain by academic institutions.
- It brings awareness for the need for clean air and may prompt further research to improve the environmental status on campus.

1.6 SCOPE OF STUDY

This study focus on analyzing atmospheric parameters (PM 2.5, temperature and relative humidity) within University of Benin main campus using PurpleAir sensor.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. INTRODUCTION TO ATMOSPHERIC PARAMETERS AND AIR QUALITY MONITORING

Air quality studies have gained more attention with the growing concern induced by urbanization, industrialization, and population rise that are inducing the deterioration of atmospheric conditions. Air pollutant measurements such as particulate matter ($PM_{2.5}$), temperature and relative humidity are at the center of making air pollution a dynamic phenomenon whose effects on the environment and human health are felt (Zhang *et al*., 2022).

The review encompasses empirical literature across the globe and in Nigeria and serves as the premise for the present study.

Atmospheric parameters are physical and chemical observable that characterize the atmospheric state at a location in space and time. Parameters such as temperature and humidity are some of the parameters. Their detection is important in identifying air quality, obtaining information on weather patterns, and identifying possible impacts on human health, plants, and infrastructure (Fiore *et al*., 2015).

2.2. SOURCES AND SPATIO-TEMPORAL VARIATIONS OF PM2.5 IN URBAN ENVIRONMENT

PM2.5 contains primary and secondary sources (atmospheric reaction and direct emission). Primary sources include vehicle exhaust, industrial emissions, and road dust resuspension, while secondary sources are aerosol formation through precursor gases like sulfur dioxide and nitrogen oxides (Manisalidis *et al*., 2020). Seasonal variation is a dominant phenomenon in urban tropical areas; dry periods, such as Nigeria's harmattan season, increase PM concentration via the transportation of dust from the Sahara Desert, as compared to dilution during rainy seasons (Odunanjo *et al*., 2024). Most cities in both developed and developing countries of the world face the problem of severe PM pollution, due to some factors mostly pertinent to urban areas (Amegah and Agyei- Mensah, 2017). Most cities in Nigeria are also susceptible to the impact of growing industrialization and increasing commercial activities on the quality of air. According to (Balogun *et al*., 2024) air borne particulates are the most obvious form of pollution in most Nigerian roads and cities. These studies identified automobile exhaust, solid waste incineration, industrial emission, fugitive dust from roads and harmattan dust as the major causes of high particulate matter concentration. The study by (Balogun and Orimoogunje 2015) reported land use activity as a relevant indicator of air quality in Benin City. Findings of the study indicate that commercial and industrial land use activities are associated with higher concentration of pollutants within a city. Other studies have also shown that exposure to PM pollution is associated with the reports of serious health issues such as breathing and nasal problems, cardiovascular diseases, lung infections and even cancers (Thangavel *et al*., 2022). In terms of environmental effects, even though PM2.5 is neither a greenhouse gas (GHG) nor precursor gas to GHGs (Balogun *et al*., 2024). Studies by (Kuklinska *et al*., 2015) and (Manisalidis *et al*., (2020) report that apart from health effects, PM2.5 is capable of limiting visibility through the formation of fog, thereby resulting to accidents along transport routes and industrial areas

2.3. AIR QUALITY STUDIES IN UNIVERSITY OF BENIN (UNIBEN)

Geo-spatial analysis in Benin City identified locations of pollution along trunk roads, market sites, and industrial areas, and spatial distribution was due to land use (Edo-Taiwo and Akpoborie, 2015). Seasonal patterns show high rates of PM in the dry season due to harmattan dust and reduced humidity, which increase pollutant dispersion (Osemwengie and Omo-Irabor, 2015).

In University of Benin, PurpleAir sensor have been installed in Space-Earth Environment Research Laboratory to monitor PM and meteorological parameters, providing useful baseline data. These studies are constrained by their expense and coarse spatial resolution and indicate the need for low-cost, campus-level monitoring solutions.

2.4. PURPLEAIR SENSORS: TECHNOLOGY AND APPLICATIONS

PurpleAir monitors are low-cost, laser-based devices that measure PM1.0, PM2.5, PM10, temperature, humidity, and pressure in real-time and send data to a cloud-enabled platform. Making them ideal for community-based air quality networks. The monitors use dual-laser particle counters to make an estimate of PM concentration and have environmental sensors for meteorological data (Clements, *et al*., 2017). Several empirical researches have demonstrated the usefulness of inexpensive sensors for tracking air quality (Crilley *et al*., 2018). In Nigeria, most of the air quality studies have employed conventional methods or short-term measurements. For example, (Ediagbonya and Ukpebor 2019) have presented elevated $PM_{2.5}$ concentrations in Benin City due to traffic and biomass burning emissions. Few studies, though, employed continuous low-cost monitoring technology.

2.4.1. Accuracy and Calibration of PurpleAir Sensors

PurpleAir sensor accuracy has been extensively studied, particularly for PM2.5. In a national study in the United States, raw PurpleAir PM2.5 measurements were approximately 40% higher than reference monitor concentrations, but agreement was enhanced by application of correction factors (Barkjohn *et al*., 2021). In hot and humid climates such as Nigeria's, calibration models that account for humidity and temperature enhance sensor reliability for ambient monitoring (Zheng *et al*., 2024). Long-term measurements in urban areas confirm that PurpleAir monitors produce consistent results for steady-state and episodic monitoring, though regular upkeep is required to reduce dust accumulation on optical parts (Kim *et al*., 2023).

2.4.2. Applications of Purpleair Sensors in Localized Studies

PurpleAir sensors are frequently used within communities as well as educational settings to monitor air quality at the hyper-local level. For instance, research conducted within New York City used PurpleAir sensors to monitor the variances in PM2.5 concentrations near schools and found higher concentrations during rush hour. In developing nations, similar applications are being introduced, with sensors installed in urban areas to supplement limited regulatory frameworks (Karagulian *et al*., 2019). On university campuses, PurpleAir sensors have been utilized to evaluate both indoor and outdoor air quality, pinpointing sources of pollution such as vehicular traffic and construction activities (Smith *et al*., 2022). These investigations underscore the sensors' capacity for detailed monitoring in settings like the University of Benin, where localized information can guide specific campus interventions.

2.4.3. Advantages of PurepleAir Sensor

- It is cost effective compared to regulatory- grade monitors enabling dense sensor networks (Barkjohn *et al*., 2021).

- Provides hyperlocal, real-time PM2.5/PM10 measurements at 2 minutes intervals (Tryner *et al*., 2020).
- Wireless data transmission and cloud-based visualization (such as PurpleAir Map) ehance accessibility (Barkjohn *et al*., 2021).

2.4.4. Limitations of PurpleAir Sensors

- Requires field calibration against reference instruments for regulatory-grade accuracy (Tryner *et al*., 2020).
- Measures only PM2.5/PM10 (not gases like O3, NO2, or CO) (Barkjohn *et al*.,2021).
- Performance degrades overtime without maintenance (Synder *et al*.,2020).

2.5. AIR QUALITY INDEX (AQI)

The Air Quality Index (AQI) is a standardized system used to communicate the level of air pollution to the public. It converts concentrations of key air pollutants such as PM2.5, PM10, ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), and sulfur dioxide (SO_2) into a single numerical scale, usually ranging from 0 to 500. The higher the AQI value, the greater the level of air pollution and the higher the health risk.

The AQI is generally divided into categories (such as Good, Moderate, Unhealthy for Sensitive Groups, Unhealthy, Very Unhealthy, Hazardous), with similar health warnings for the public. PM2.5 often has a tendency to drive the calculation of the AQI in urban areas. The AQI is an important tool for public health communication and has robust associations with adverse health outcomes, especially in populations exposed to high levels PM2.5 and ozone" (Chen *et al*., 2013).

AQI	Health concern level	AQI daily colour code	Air pollution level
0 – 50	Good	Green	Level 1
51 – 100	Moderate	Yellow	Level 2
101 – 150	Unhealthy for sensitive groups	Orange	Level 3
150 – 200	Unhealthy	Red	Level 4
201 – 300	Very Unhealthy	Purple	Level 5
301 and above	Hazardous	Marron	Level 6

Table 2.1. Air Quality Index.

(Chen *et al.,* 2013)

Presents in Table 1 are the six major classifications of the AQI i.e level of health concern, colour code and also level of air pollution. Air quality Level 1 with colour code green indicates clean and healthy air with little or no health risk. Level 2 with colour code yellow also connotes an acceptable level of air pollution but there may be moderate health concern for group of people that are highly sensitive to air pollution. However, this sensitive group of people are usually small in number. Level 3 (colour code orange) is considered to be unhealthy for sensitive groups such as the group of people living underlying illness (e.g. lung disease, heart disease, etc) and also the vulnerable groups like elderly people and the children. These sensitive sets of people are usually at great risk but the general public may be unaffected. Level 4 (colour code red) is termed unhealthy and the air quality here may pose negative health effect on some members of the general public, while the sensitive and vulnerable groups may experience more serious health issues. Level 5 (colour code purple) implies a serious health alert for the general public. Air quality at this level is very unhealthy and the risk of health effects is high for everyone and severe for the sensitive groups. The last level with colour code maroon indicates a hazardous level of health concern. Air pollution at Level 6 will trigger an emergency warning of health conditions and the entire exposed population is more likely to be affected (Wambebe and Duan 2020).

2.6. HEALTH AND ENVIRONMENTAL IMPACTS OF PM2.5 EXPOSURE

Exposure to PM2.5 poses long-term implications. From a health perspective, short-term exposure causes respiratory irritation, while long-term exposure has been associated with cardiovascular diseases, lung cancer, and early death (Ghorani-Azam *et al*., 2016). The World Health Organization places air pollution as the cause of 7 million early deaths yearly with categories like children and the old being most affected (Kan, 2022). In Nigeria, (Amegah and Agyei-Mensah 2017) credited exposure to urban PM in Accra and Lagos as causing increased asthma and hypertension rates, underscoring sub-Saharan Africa's neglected burden. Environmentally, PM2.5 reduces visibility through scattering light and causing fog, and it has the ability to escalate road accidents (Kuklinska *et al*., 2015). Although not a greenhouse gas in direct action, it impacts radiative forcing through bouncing back solar radiation (Balogun and Odjugo, 2022). (Manisalidis *et al*., 2020) elucidated how PM2.5 alters ecosystems by leaving behind heavy metals, affecting water and soil quality. In Benin City, (Ukpebor *et al*., 2021) surveyed residents, finding 60% reporting respiratory symptoms correlated with PM peaks, highlighting the socio-economic dimensions.

2.7 WORLD HEALTH ORGANIZATION (WHO) AIR QUALITY GUILDIENCE:

The World Health Organization (WHO) has established Air Quality Guidelines

(AQGs) that include recommended “safe” (or health-protective) levels for fine particulate matter ($PM_{2.5}$)

The WHO guideline value $PM_{2.5}$ (fine particles ≤ 2.5 µm) as of the most recent update:

Average Period	WHO Guideline	Notes/Context
Annual mean	5 µg/m^3	The 2021 guideline revision lowered the long term exposure threshold from 10 to 5 µg/m^3
24-hour mean	15 µg/m^3	This is intended to limit short-term peaks/exposure.

Table 2.2: Showing WHO Guideline for $PM_{2.5}$

(Adjei andAfriyie, 2025)

- These guidelines are not legally binding limits, but are recommendations intended to guide policy and regulatory standards.
- WHO deliberately set these more stringent values based on accumulating evidence that health risks from $PM_{2.5}$ are present even at lower concentrations.
- In practice, many countries have ambient $PM_{2.5}$ concentrations that exceed these WHO guideline levels.

- Some scientific assessments suggest that there is no truly “safe” threshold for $PM_{2.5}$, even very low concentrations are associated with incremental health risks (especially for cardiovascular, respiratory, and mortality outcomes).

CHAPTER THREE

3.0 MATERIALS AND METHODOLOGY

3.1 RESEARCH DESIGN

This study utilized experimental and observational research design. The PurpleAir monitor was installed at a selected spot in University of Benin (UNIBEN) to quantify particulate matter (PM2.5), temperature, and relative humidity. The selected design can analyze temporal variations of atmospheric parameters and real-time observation of the environment.

3.2 DESCRIPTION OF STUDY AREA

The research was conducted at the University of Benin (UNIBEN), Ugbowo Campus, Benin City, Edo State, Nigeria. UNIBEN is a model federal university in Nigeria established in 1970 and has a vast area that covers various human activities that can lead to atmospheric conditions. The university campus is a representation of both semi-urban and mini-urban environmental processes and thus is the most suitable location to observe atmospheric conditions such as particulate matter (PM2.5), temperature, relative humidity, and atmospheric pressure using PurpleAir sensors.

3.3 GEOGRAPHICAL AND PHYSICAL CHARACTERISTICS

The University of Benin is situated in the south of Nigeria, off the Benin-Lagos expressway. Geographically, it is situated between 6.39°N and 5.62°E with a mean elevation of approximately 74 meters above sea level. The Ugbowo Campus occupies a total area of approximately 1,200 hectares, consisting of a range of land-use classes including academic complexes, administrative buildings, student hostel, staff quarters, recreational buildings, green spaces, and internal road networks.

3.3.1 Site of Justification

Human and Environmental Activities

The Ugbowo campus, which University of Benin is surrounded by a mix of peri urban and urban activities, including residential areas (e.g., Ekosodin and BDPA), commercial areas, and roads like the Lagos-Benin Expressway, which are generators of vehicular emissions and potential sources of air pollution.

3.3.1.1 Vehicular Traffic: There is moderate to heavy traffic on internal roads within the campus, particularly during school peak hours, due to the movement of visitors, students, and staff.

3.3.1.2 Power Generators: Diesel generators serve hostels, faculties, and administrative buildings due to irregular supply of electricity hence releasing pollutants such as PM2.5, carbon monoxide and nitrogen oxide into the air leading to localized air pollution

3.3.1.3 Construction and Industrial Activities: Occasional construction activities, roadworks, and small-scale industrial activities particularly during dry season can generate dust and particulate matter.

3.4 MATERIALS AND INSTRUMENTATION

3.4.1 Materials

Power supply, internet connectivity, mounting stand, protective cover, logbook.

3.4.2 Instruments

PurpleAir sensor, computer system, data analysis software.

3.4.3 Sensor Siting Specifications

PurpleAir sensor was installed in strict adherence to general best practices for monitoring air quality

3.4.3.1 Location: University of Benin, Edo State, Nigeria, rooftop of Space-Earth Environment Research Laboratory.

3.4.3.2 Height: Approximately 10 meters above ground level. Such a height diminishes the immediate impact of resuspension of dust at ground level.

3.4.3.3 Exposure: The sensor was positioned such that there was free airflow around the inlet far from obstructions.

3.5 METHODOLOGY

The primary instrument use was the PurpleAir-II-SD sensor

3.5.1 Measured parameters:

- PM2.5 concentrations: ($\mu g/m^3$)
- Temperature (°C)
- Relative Humidity (%)

These parameters were continuously monitored using the PurpleAir within the study area.

3.5.2 Data Collection

PurpleAir sensor was installed correctly within its manufacturer provided weather proof enclosure. The device was powered on with a constant supply of power and configured to send data through the local Wi-Fi network to PurpleAir cloud platform. The data was recorded every 120 seconds (2 minutes) throughout the study period. Continuous monitoring was carried out for 3 months January 2025 to March 2025.

3.6 DATA PROCESSING ANALYSIS

Data from the PurpleAir online platform was downloaded in CSV format.

The raw dataset was cleaned in Microsoft Excel to remove outliers, erroneous entries, or missing data points.

Graphical representations such as time-series plots were generated to show daily and weekly variations.

Correlation analysis was carried out to determine the relationship between PM2.5 levels, temperature, and humidity.

Results were compared with the World Health Organization (WHO) air quality guidelines and Nigerian Federal Ministry of Environmental standards to assess compliance.

3.7 VALIDATION OF SENSOR MEASUREMENT

The PurpleAir sensor readings for temperature and humidity were cross-checked against standard thermometer and hygrometer readings.

3.8 ETHICAL AND SAFETY CONSIDERATIONS

Although this study was aimed at environmental parameters and did not involve direct human or animal subjects, several ethical issues were still taken into consideration which include;

3.8.1 Permission and Authorization

There was clearance from the Space Earth Environment Research Laboratory before deploying the PurpleAir sensor. The sensor locations were selected in consultation with the unit concerned (Space-Earth Environment Research

Laboratory, University of Benin) to exclude arguments of unauthorized installations.

3.8.2 Non-Interference with Human Subjects

No personal data of students', staff, or visitors were collected during the study. Monitoring was solely environmental, and confidentiality and privacy were ensured.

3.8.3 Health and Safety

The sensor was installed safely on wall at a level that would prevent accidents. Electrical connections (surge protectors, extension wires) were installed as per safety requirements to prevent shock, fire, or obstruction to movement.

3.8.4 Environmental Responsibility

Equipment installation did not cause any harm to the environment (no digging or disturbance of natural habitats). The equipment was kept in protective weather shields to minimize risk of contamination or harm to the environment.

3.8.5 Data Integrity and Transparency

Data acquired were kept secure and utilized for academic purposes only. No falsification, manipulation, or selective reporting of results were conducted.

3.8.6 Respect for Community and Institutional Norms

Set-ups were positioned in a way that would not interfere with normal campus activities (pedestrian traffic, classrooms, or restricted areas). Security issues were considered by informing campus security of the monitoring site to prevent vandalism or theft.

CHAPTER FOUR
RESULT

The PurpleAir sensor recorded real-time data at 2 minutes' intervals. The processed data were averaged to obtain daily values of $PM_{2.5}$ concentration (µg/m^3), temperature (°C), and relative humidity (%). Atmospheric data collected within Space Earth Environment Research Laboratory during January, February and

March respectively are presented in the tables below and the Analysis of the Atmospheric Parameters is presented in the graphs below.

Table 4.1: Daily Average of Atmospheric Parameters for the Month of January

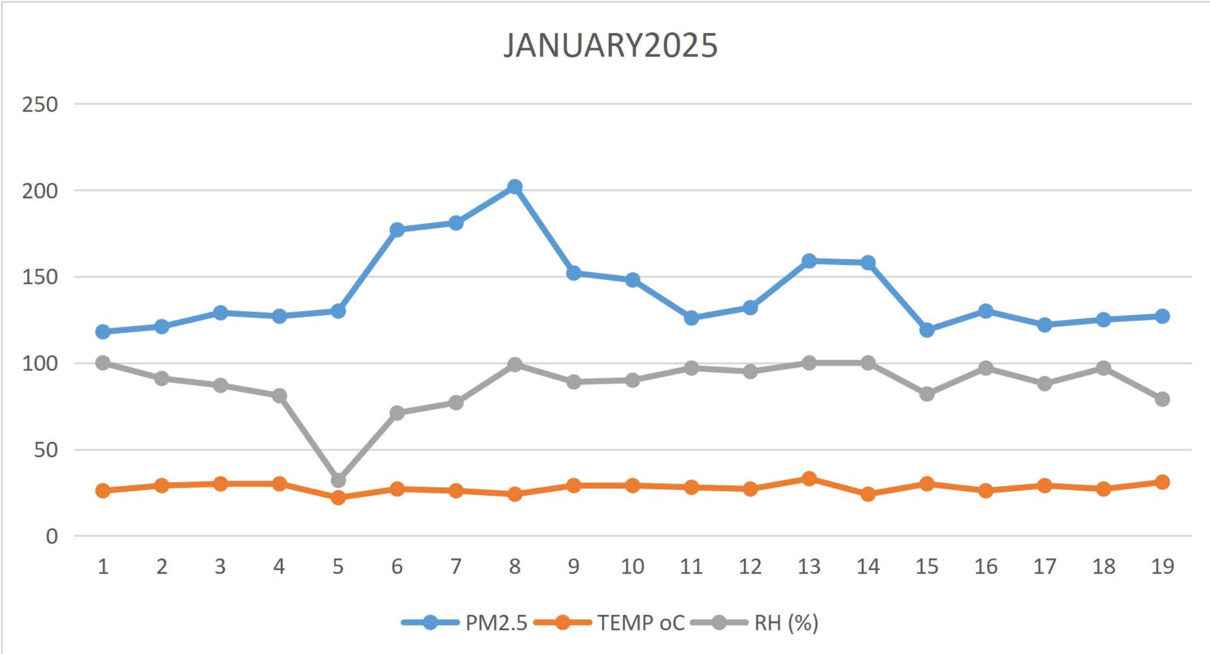
Date	PM2.5	TEMPRATURE(C)	RELATIVE HUMIDITY (%)
3 01 2025	118	26	100
4 01 2025	121	29	91
5 01 2025	129	30	87
6 01 2025	127	30	81
11 01 2025	130	22	32
12 01 2025	177	27	71
13 01 2025	181	26	77
14 01 2025	202	24	99
16 01 2025	152	29	89
17 01 2025	148	29	90
18 01 2025	126	28	97
19 01 2025	132	27	95
20 01 2025	159	33	100
21 01 2025	158	24	100
26 01 2025	119	30	82
27 01 2025	130	26	97
28 01 2025	122	29	88
29 01 2025	125	27	97
31 01 2025	127	31	79

Table 4.2: Daily Average of Atmospheric Parameters for the Month of February

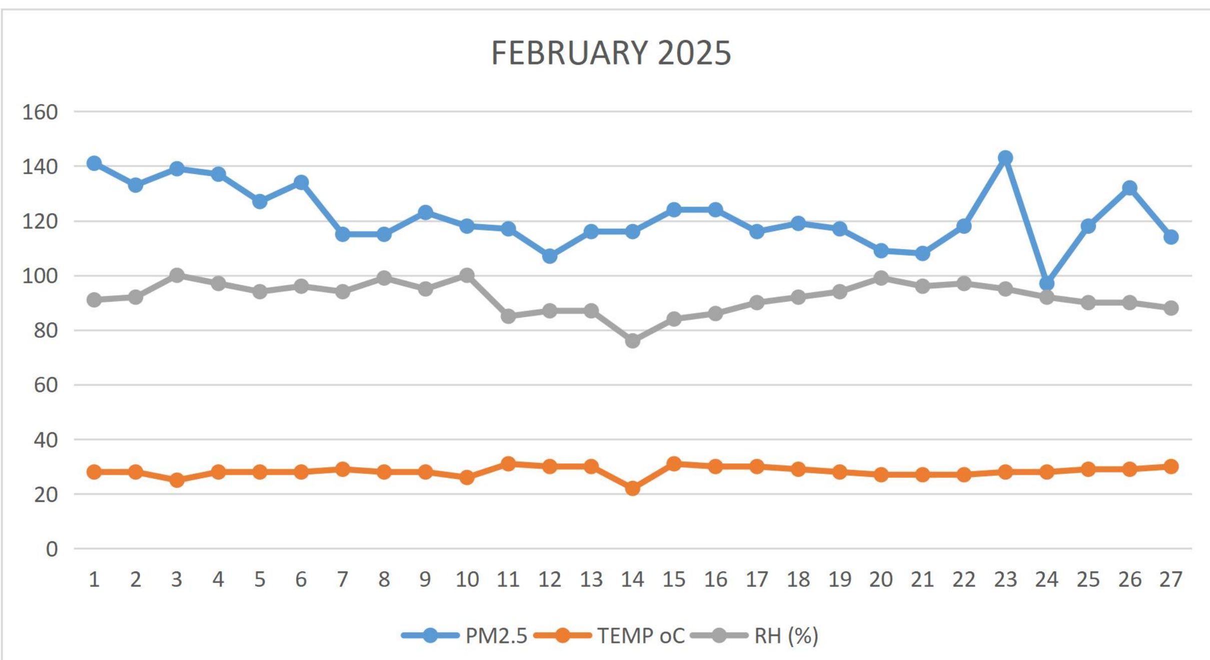
Date	PM2.5	TEMPRATURE(C)	RELATIVE HUMIDITY(%)
1 02 2025	141	28	91
2 02 2025	133	28	92
3 02 2025	139	25	100
4 02 2025	137	28	97
5 02 2025	127	28	94
6 02 2025	134	28	96
7 02 2025	115	29	94
8 02 2025	115	28	99
9 02 2025	123	28	95
10 02 2025	118	26	100
11 02 2025	117	31	85
12 02 2025	107	30	87
13 02 2025	116	30	87
14 02 2025	116	22	76
16 02 2025	124	31	84
17 02 2025	124	30	86
18 02 2025	116	30	90
19 02 2025	119	29	92
20 02 2025	117	28	94
21 02 2025	109	27	99
22 02 2025	108	27	96
23 02 2025	118	27	97
24 02 2025	143	28	95
25 02 2025	97	28	92
26 02 2025	118	29	90
27 02 2025	132	29	90
28 02 2025	114	30	88

Table 4.3: Daily Average of Atmospheric Parameters for the Month of March

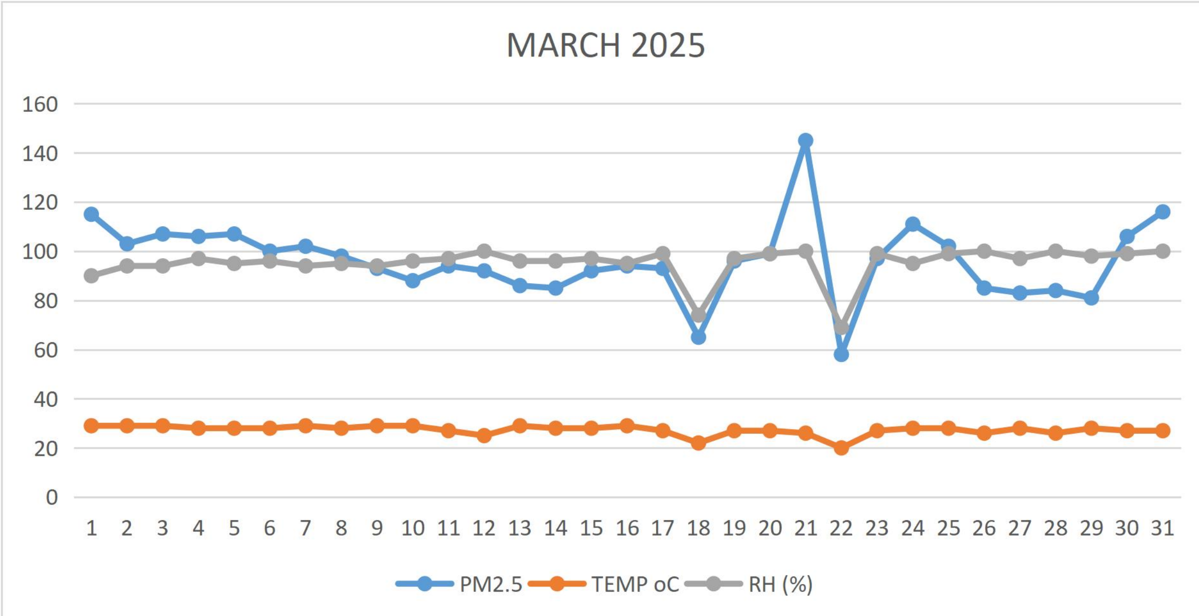
Date	PM2.5	TEMPRATURE(C)	RELATIVE HUMIDITY(%)
1 03 2025	115	29	90
2 03 2025	103	29	94
3 03 2025	107	29	94
4 03 2025	106	28	97
5 03 2025	107	28	95
6 03 2025	100	28	96
7 03 2025	102	29	94
8 03 2025	98	28	95
9 03 2025	93	29	94
10 03 2025	88	29	96
11 03 2025	94	27	97
12 03 2025	92	25	100
13 03 2025	86	29	96
14 03 2025	85	28	96
15 03 2025	92	28	97
16 03 2025	94	29	95
17 03 2025	93	27	99
18 03 2025	65	22	74
19 03 2025	96	27	97
20 03 2025	99	27	99
21 03 2025	145	26	100
22 03 2025	58	20	69
23 03 2025	97	27	99
24 03 2025	111	28	95
25 03 2025	102	28	99
26 03 2025	85	26	100
27 03 2025	83	28	97
28 03 2025	84	26	100
29 03 2025	81	28	98
30 03 2025	106	27	99
31 03 2025	116	27	100



Graph 4.1: Shows the Analysis of Atmospheric Parameter for January



Graph 4.2: Shows the Analysis of Atmospheric Parameter for February



Graph 4.3: Shows the Analysis of Atmospheric Parameter for March

CHAPTER FIVE

5.0 DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 DISCUSSION

5.2 TABLE REPRESENTATION

Table 4.1, 4.2 and 4.3 shows the atmospheric data collected in Space Earth Environment Research Laboratory during January, February and March, 2025 using PurpleAir sensor. It contains daily values of $PM_{2.5}$ concentrations, temperature and relative humidity.

5.2.1 January (Table 4.1)

5.2.1.1 $PM_{2.5}$ (Particulate Matter ≤ 2.5 µm)

The concentration of airborne fine particles that reach deep lungs. The $PM_{2.5}$ range is between 118 and 202 µg/m³, which is significantly above the WHO safe limit (25 µg/m³). Highest pollution was measured on Jan 14 (202 µg/m³) a high value. Most values were above 120, indicative of poor air quality overall. High levels of $PM_{2.5}$ are linked to low humidity and high temperature on the majority of days, typical of the dry season. For example, on Jan 14, $PM_{2.5}$ went as high as 202 with moderate temperature (24°C) and high humidity (99%) to demonstrate that humidity cannot single-handedly repress pollution during dry season. Days like Jan

11 (low humidity, low temperature) still showed high $PM_{2.5}$ (130), confirming poor air quality despite cooler temperatures.

5.2.1.2 Temperature (°C)

Temperature (°C) 22°C to 33°C typical of dry-season climate in Benin City. Highest temperature was Jan 20 (33°C). Lower temperatures like 22°C for Jan 11 were felt alongside low humidity, which is most probably caused by harmattan effects.

5.2.1.3 Relative Humidity (%)

Between 32% and 100%, with much day-to-day variation. Lowest relative humidity was Jan 11 (32%), a likely harmattan maximum, associated with dry, dusty conditions. Highest relative humidity (100%) was on Jan 3, 20, and 21, possibly indicating alterations in weather or rain.

5.2.2 February (Table 4.2)

5.2.2.1 $PM_{2.5}$ (Particulate Matter 2.5)

PM2.5 (Particulate Matter 2.5) indicates the concentration of fine inhalable particles in the air (in $\mu g/m^3$), which are harmful to human health, especially the lungs. Values range from 97 to 143, with readings primarily above 100 consistently, indicating unhealthy air for the sensitive population. Highest value 143 on Feb 24, which indicates extreme pollution. Lowest value 97 on Feb 25, the only day with relatively good air quality.

5.2.2.2 Temperature (°C)

There were temperatures between 22°C and 31°C typical of the tropical southern Nigeria climate. The peak, 31°C, on Feb 11 and 16, and the minimum, 22°C, on Feb 14. This could influence $PM_{2.5}$ levels as high temperatures can speed up chemical reactions in the air that cause particulate formation.

5.2.2.3 Relative Humidity (%)

Humidity ranges from 76% to 100%, which indicates non-stop humid conditions common to the region. The highest humidity (100%) was experienced on Feb 3 and 10, while the lowest humidity (76%) was experienced on Feb 14. High humidity has the ability to reduce airborne particulate matter levels by settling particles, although the effect will vary depending on conditions.

5.2.3 March (Table 4.3)

5.2.3.1 $PM_{2.5}$ (Particulate Matter 2.5)

PM2.5 Measured in micrograms per cubic meter ($\mu g/m^3$) - $PM_{2.5}$ refers to small airborne particles harmful to human health when inhaled. Values range from 58 to 145, peaking on March 21 (145) and March 1 (115), which indicates poor air quality on those days. Below 100 typically indicates moderate air quality, while above 100 indicates unhealthy amounts

5.2.3.2 Temperature (°C)

The range of temperatures is between 20°C and 29°C. The lowest recorded temperature was 20°C on March 22, while the highest was 29°C was recorded on multiple days. This also indicates a tropical climate pattern that is common with the climate of Benin City in March.

5.2.3.3 Relative Humidity (%)

Humidity is 69% to 100%. Extremely high humidity is registered in the majority of days, typical of southern Nigeria's wet season. March 22 but has the lowest humidity (69%) corresponding to its low temp and $PM_{2.5}$ reading, perhaps due to weather patterns like rain or wind that scatter contaminants.

5.3 GRAPH REPRESENTATION

Graph 4.1, 4.2 and 4.3 presents the analysis of atmospheric parameter recorded within Space Earth Environmental Research Laboratory using a PurpleAir for January, February and March, 2025. Parameters plotted are:

- $PM_{2.5}$ (Particulate Matter ≤ 2.5 μm) - Blue line

- Temperature (°C) - Orange line
- Relative Humidity (RH %) - Grey line

5.3.1 January (Graph 4.1)

5.3.1.1 $PM_{2.5}$ (Blue Line)

PM2.5 levels vary from, 110 µg/m³ to 200 µg/m³, with a large spike on Day 8 at 200 µg/m³. Day 6 to 10 see high $PM_{2.5}$ levels with bad air quality, perhaps due to greater emissions or stagnant air. After Day 10, $PM_{2.5}$ falls somewhat but remains above 100 µg/m³ which is still unhealthy.

5.3.1.1.1 $PM_{2.5}$ Pollution:

Elevated $PM_{2.5}$ signifies continued air pollution, perhaps from traffic, open burning, or generator use, common in urban environments. Day 8 spike could represent a localized pollution event or meteorological phenomenon that trapped pollutants.

5.3.1.2 Temperature (Orange line)

Temperature is relatively constant at 25°C to 30°C. There is a minor dip around day 6–8 corresponding to high RH. This temperature range is typical for southern Nigeria in January (dry season). The relative constancy of temperature with RH and $PM_{2.5}$ fluctuation indicates that particulate matter and humidity are more sensitive to local or regional atmospheric processes compared to temperature at this period.

5.3.1.3 Relative Humidity (RH %) (Grey Line)

Relative humidity is generally 80% to 100% but drops drastically on Day 6 (50%) before recovering. After this, RH is high with minor fluctuations. Lower RH on Day 6 tallies with comparatively lower temperature and may reflect a dry dusty condition (possible harmattan influence).

5.3.2 February (Graph 4.2)

5.3.2.1 $PM_{2.5}$ (Blue Line)

$PM_{2.5}$ levels normally vary between 100–140 µg/m³, which is unhealthy, especially for sensitive groups. There is a huge spike on Day 23 (above 140 µg/m³), followed by a bigger drop on Day 24, and another spike on Day 26. This could be indicating short-term pollution events, such as:

- Generator use
- Open burning
- Meteorological conditions such as calm winds trapping pollutants

5.3.2.2 Temperature (°C) (Orange Line)

The temperature is relatively stable, typically between 28°C and 30°C. There is a slight dip on Day 13–14, possibly due to increased RH. The temperature typically follows a normal dry-season on February.

5.3.2.3. Relative Humidity (RH %) (Grey Line)

RH is 80–100%, normal for south Nigeria. There is a sharp fall at Day 13–14 (75%), likely reflects a drier period. RH picks up a bit after Day 14 and falls again at the end of the month.

5.3.2.3.1 $PM_{2.5}$ vs RH:

PM2.5 also peaks when RH is low (Day 23), perhaps reflecting dry air exacerbating suspension of dust or pollution. $PM_{2.5}$ is consistently higher than WHO safe levels (35 µg/m³), indicating chronic exposure risk to students/staff on campus.

Temperature is stable, but there is more variation in RH and $PM_{2.5}$, indicating that air quality is more influenced by emissions and humidity than temperature.

5.3.3 March (Graph 4.3)

5.3.3.1. PM2.5 (Blue Line)

PM2.5 is 80–110 μg/m³ for most of the month, indicating poor to unhealthy air quality.

Sharp drop on Mar 18–19, then a sudden rise on Mar 21 (to 140 μg/m³), followed by a drop on Mar 23.

Such abrupt changes reflect:

- Possible pollution events (such as heavy generator operation, bush burning).
- Wind or rain condition changes for particle dispersal.

5.3.3.2 Temperature (Orange Line)

Temperature is consistently 28–30°C. It goes down on March 22–23, which coincides with the $PM_{2.5}$ drop and may be due to rain or cloudy weather.

5.3.3.3. Relative Humidity (RH %) (Grey Line)

RH is quite stable (90%), with decreases evident around Mar 18–19 and again around Mar 23. The negative correlation between RH and $PM_{2.5}$ is clear: low RH days are those with $PM_{2.5}$ peaks, suggesting drier air exacerbates dust and suspended particles.

5.3.3.3.1 Air Pollution

Air pollution is ongoing, with $PM_{2.5}$ well above WHO safe levels (≤35 μg/m³), Short-term peaks reflect specific local activity or environmental conditions.

Humidity and $PM_{2.5}$ are inversely correlated in a unique way as RH decreases, $PM_{2.5}$ increases, possibly due to the fact that there is less water content in the air to trap or settle out particles. Temperature is fairly constant and has less influence on $PM_{2.5}$ than RH.

5.4 CONCLUSION

The study successfully monitored and analyzed $PM_{2.5}$, temperature, and relative humidity within the University of Benin using a PurpleAir sensor, revealing significant air quality concerns. Across the study period, $PM_{2.5}$ concentrations consistently exceeded WHO safety thresholds, confirming poor air quality conditions on campus. The results indicate that the major contributors to pollution include vehicular emissions, generator exhausts, and seasonal dust (harmattan). Temperature remained within the expected tropical range, while relative humidity showed wide variation, inversely influencing $PM_{2.5}$ levels. The data underscore the vulnerability of the university community particularly students and staff to adverse health effects from particulate exposure. The use of PurpleAir sensors proved to be a reliable and affordable approach for continuous environmental monitoring, supporting data-driven decision-making for campus air quality management.

5.5 RECOMMENDATIONS

1. **Establishment of Air Quality Monitoring Stations:** The university should install additional PurpleAir sensors at strategic campus locations to create a network for continuous real-time monitoring.
2. **Public Awareness and Health Education:** Awareness campaigns should be conducted to educate students and staff on the health risks of air pollution and preventive measures.
3. **Promotion of Clean Energy Sources:** The institution should gradually reduce the use of diesel-powered generators by investing in renewable energy systems such as solar panels.
4. **Tree Planting and Green Infrastructure:** More trees and green zones should be established across the campus to enhance air filtration and provide thermal comfort.
5. **Regulation of Vehicular and Industrial Activities:** Limit unnecessary vehicular traffic, discourage open burning, and ensure strict maintenance of campus vehicles and generators to reduce emissions.
6. **Integration into Policy and Research:** The air quality data generated should inform environmental policies, research studies, and sustainability planning at the University of Benin.

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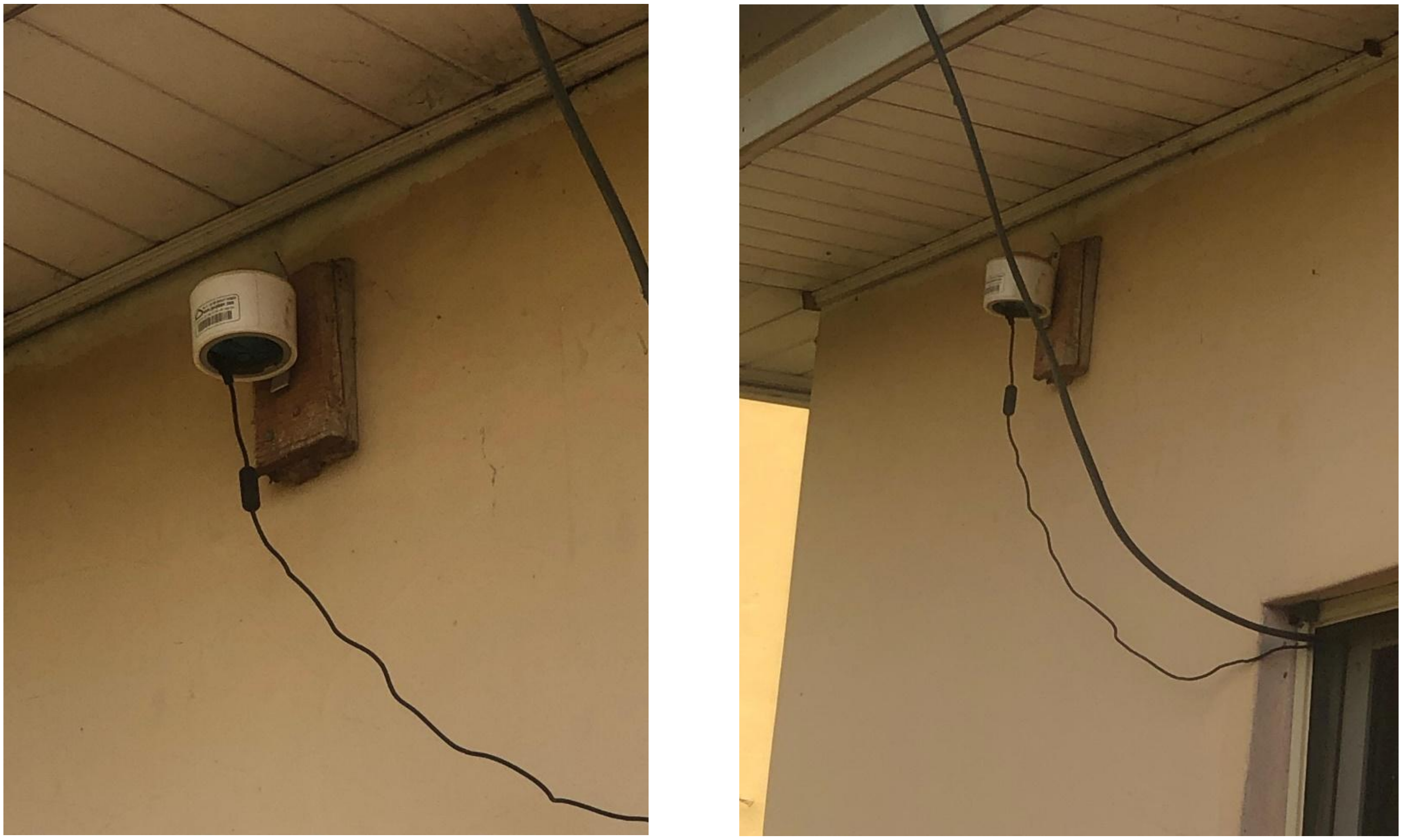
APPENDIX



PurpleAir Sensor Installed in University of Benin (UNIBEN)