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Evaluation of Ambient Air Quality Levels at Various Locations Within Lead City University, Ibadan

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Abstract

Background: Air quality in university environment is strongly affected by the student population explosion, climatic conditions and industrial activity within the institution. Monitoring the main air pollutants such as carbon dioxides, carbon monoxide and particulate matter may help control the most polluted areas of the institution and take measures to reduce the pollution.Universities are big metropolitan institutions with sizable populations of students, employees, and visitors. However, university settings can contribute to air pollution, with diverse activities such as lab work, cooking in dorms, and vehicle traffic, among others, causing interior and ambient air pollution. It is impossible to estimate how much air pollution affects the health and happiness of students without embarking on this type of research work.

Purpose/Aim: Evaluation of meteorology parameters (i.e. temperature and relative humidity (RH)) and ambient air quality (CO, CO_2 and particulate matter ($PM_{2.5}$)) level at various locations within Lead City University, Ibadan is essential.

Methodology: Ambient concentrations of carbon monoxide (CO), carbon dioxide (CO_2), Relative humidity (RH), Temperature (TEMP), and Particulate Matter ($PM_{2.5}$) were measured in 15 locations across Lead City University over a two-week period (between 25th of June 2023 and 3rd of August 2023) with Bosean air quality detector -T-201.

Results: Morning temperatures in all the locations measured ranging from 23.7°C to 29.2°C while afternoon temperature fluctuates more significantly, with the lowest recorded at 27.2°C and the highest at a notably warmer 35.8°C in all the locations measured. The morning RH levels ranging from 63.8% to 74.7% while afternoon RH values, ranging from 58.2% to 63.4%. The finding also shows that afternoon CO_2 levels range from 468.5 ppm to 971.6 ppm, with Location 13 having an unusually high average. Morning CO levels ranging from 4.1 ppm to 49 ppm, with location 13 showing the most highest figure of 184.2 ppm. CO_2 and CO levels are mostly within acceptable ranges as recommended by World Health Organization (WHO) that CO_2 concentration levels in school buildings should kept below 1000 ppm and CO be below an average of nine parts per million (ppm) for any eight-hour period, and below 25 ppm for any one-hour period as an indicative benchmark of good indoor air quality (IAQ).

Morning RH values range from 63.8% to 74.7%, with Location 1 having the highest average while afternoon RH values are between 58.9% and 67.7%, with Location 6 having the highest average. The relatively narrow variance in RH indicates that the dataset predominantly represents conditions with moderate humidity levels. Morning PM levels vary from 8.9 to 17.1µg/m³, suggesting diverse air quality conditions across the samples. In the afternoon, PM concentrations display a broader range, from 8.9 to an exceptionally high 436.1 in Location 13. Interestingly, all the air pollutants measured are still within the USA EPA permissible level of the National Ambient Air Quality Standard for $PM_{2.5}$, which is 35 µg/m^3, and CO, which is 40 mg/m^3 and CO_2 between 400 - 1,000ppm

Conclusion: Variability in these parameters has implications for human health therefore, adequate ventilation and pollution control measures is thereby recommended for the university management in order to improve indoor air quality.

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1. Introduction

Air pollution is a significant environmental concern, with adverse effects on human health and the environment. The World Health Organization (WHO) estimates that air pollution is responsible for 4.2 million deaths annually, with the majority occurring in low and middle-income countries (World Health Organization. (2018). In Nigeria, air pollution has been identified as a major public health challenge, with several studies reporting high levels of ambient and indoor air pollutants (Oguntoke, O. et al (2019) and Akinola, M. O. et al (2020). The situation is particularly concerning in urban areas, where rapid industrialization and urbanization have led to an increase in the emission of pollutants into the atmosphere (Brook, R. D. et al (2010).

Universities are important institutions in urban areas, with a significant population of students, staff, and visitors. However, university environments can contribute to air pollution, with various activities such as laboratory experiments, cooking in hostels, and vehicular traffic, among others, contributing to indoor and ambient air pollution (Brook, R. D. et al (2010). The impact of air pollution on the health and well-being of university populations cannot be overstated as a results of large number of students in small area receiving lecture. Also a lot of laboratory activities do produce CO and CO_2 gases. Several studies have reported adverse health effects associated with exposure to air pollution, including respiratory and cardiovascular diseases, among others (Akinola, M. O. et al (2020).

Air pollutants are substances that have harmful effects on human health and the environment. Some of the most common air pollutants include particulate matter (PM), carbon dioxide (CO_2), and carbon monoxide (CO). These pollutants can come from both natural and human-made sources, such as industrial emissions, vehicular traffic, and burning of fossil fuels (Oguntoke, O. e tal (2019).

particulate matter (PM) is a major component of air pollution and consists of tiny particles suspended in the air. These particles can vary in size and composition, with PM_{10} referring to particles with a diameter of 10 micrometers or less and $PM_{2.5}$ referring to particles with a diameter of 2.5 micrometers or less. Sources of particulate matter include combustion processes, such as vehicle exhaust, industrial emissions, and the burning of fossil fuels for power generation. Exposure to particulate matter has been linked to respiratory and cardiovascular diseases, as well as increased mortality rates (Brook, R. D. et al (2010).

nitrogen dioxide (NO_2) is a toxic gas primarily produced by the burning of fossil fuels in vehicles, power plants, and industrial processes. It is a key indicator of air pollution resulting from combustion processes. Exposure to nitrogen dioxide can cause respiratory problems, especially in individuals with pre-existing respiratory conditions like asthma (Akinola, M. O. et al (2020).

sulfur dioxide (SO_2) is another toxic gas released during the burning of fossil fuels, particularly high-sulfur coal and oil. Industrial processes, such as smelting and refining operations, are also significant sources of sulfur dioxide emissions. Inhalation of sulfur dioxide can lead to respiratory issues, including bronchoconstriction and aggravation of asthma symptoms (Brook, R. D. et al (2010).

Ozone (O_3), a gas found in both the upper atmosphere (stratosphere) and near the ground (troposphere), plays a crucial role in the Earth's atmosphere. While stratospheric ozone protects us from harmful ultraviolet (UV) radiation, ground-level ozone can be harmful to human health. Ground-level ozone forms when nitrogen oxides and volatile organic compounds (VOCs) react in the presence of sunlight. Sources of nitrogen oxides and VOCs include vehicle exhaust, industrial emissions, and chemical solvents. Exposure to ground-level ozone can lead to respiratory issues, including chest pain, coughing, and throat irritation (Ciencewicki, J., & Jaspers, I. (2017).

Carbon monoxide (CO) is a toxic gas that can cause headaches, dizziness, and nausea. It is produced by incomplete combustion of fossil fuels, such as in vehicles and generators.

Lead (Pb) is a heavy metal that can cause neurological and developmental problems in children. It comes from sources such as leaded gasoline and industrial emissions. Volatile organic compounds (VOCs) are organic chemicals that can have both short- and long-term health effects, such as eye, nose, and throat irritation, headaches, and damage to the liver, kidneys, and central nervous system. They come from sources such as paints, solvents, and cleaning products (World Health Organization, (2019)).

Exposure to these air pollutants can have various health effects, including respiratory and cardiovascular problems, neurological and developmental problems, and an increased risk of cancer. It is crucial to monitor and regulate air pollutants to safeguard human health and protect the environment. This involves the collection of indoor air quality data and compare it with WHO standards and guidelines in order to help limit the concentration of pollutants in the air and minimize their adverse effects on human health and the environment.

However, air pollution is a significant environmental challenge that affects public health and the environment. Universities, as important institutions in urban areas, have a responsibility to promote a healthy and safe environment for their populations. This study is timely, as it aims to assess the ambient air quality levels at different areas inside Lead City University, Ibadan, with the aim of identifying potential sources of pollution and developing strategies to improve indoor and ambient air quality. Hence, the findings of the study will be useful in promoting a healthier and safer environment for students, staff, and visitors.

The main objective of this study is to assess the ambient air quality at different areas within Lead City University, Ibadan.

The specific objectives are to;

1. To measure the ambient air qualities of the following parameters, relative humidity (Indoor and outdoor), Carbon dioxide, Carbon monoxide, temperature (indoor and outdoor) and Particulate matters ($PM_{2.5}$) at various locations within Lead City University, Ibadan.
2. To investigate the potential sources of air pollutants within the university environment, including transportation, energy use, and natural phenomena.
3. To analyze the data collected from air quality monitoring equipment using statistical methods to determine the levels and sources of air pollutants.
4. To compare the concentrations of air pollutants measured within the university environment against national and international air quality standards and action levels.
5. To provide recommendations for effective air quality management strategies based on the findings of the study.

Research questions include but not limited to;

1. What are the concentrations of humidity (Indoor and outdoor), Carbon dioxide, Carbon monoxide, temperature (indoor and outdoor) and Particulate matters ($Pm_{2.5}$) at various locations within Lead City University, Ibadan.
2. What are the potential sources of air pollutants within the university environment, including transportation, energy use, and natural phenomena?
3. Comparison between the concentrations of air pollutants measured within Lead City University, Ibadan compare to WHO air quality standards and action levels?
4. What are the levels and sources of air pollutants measured by air quality monitoring equipment?
5. What recommendations can be made for effective air quality management strategies based on the findings of the study?

The scope of this study is to assess the ambient air quality levels at different areas within Lead City University, Ibadan between 25th of June 2023 and 3rd of August 2023. The study will focus on measuring the concentrations of air pollutants, including temperature, particulate matter (PM), carbon dioxide (CO_2), carbon monoxide (CO) and relative humidity at various locations within the university. The study will also investigate the potential sources of these pollutants, such as transportation, energy use, and natural phenomena.

The study will be conducted over a period of time to capture variations in air quality levels due to changes in weather, seasonal factors, and human activities. The study will cover different areas within the university, including academic buildings, residential areas, and open spaces.

The study is limited to Lead City University, Ibadan, and may not be generalization to other universities or locations in Nigeria.

2. Materials and Methods

2.1. Study Area

Lead City University is a private university located in Ibadan, Oyo State, Nigeria. It is situated in the Jericho area of Ibadan, a major city in southwestern Nigeria. The university is easily accessible, being located close to major transportation routes.

Lead City University occupies a sizable campus with well-maintained facilities and has an enrollment range of 8,000-8,999 students and range of 250-299 academic employees making it a medium-sized institution. The campus encompasses various faculty buildings, administrative offices, lecture halls, laboratories, law lecture theatre, gymnasium, student hostels, university hospital and Senate building.

Lead City University, being a self-contained institution, has its own utilities and infrastructure, including electricity, water supply, and waste management systems. The university is committed to maintaining a safe and conducive environment for its students, faculty, and staff.

It is within this university setting that the assessment of ambient air quality levels will be conducted, focusing on various areas or zones within the campus to evaluate potential variations in air quality based on the activities and characteristics of those locations.

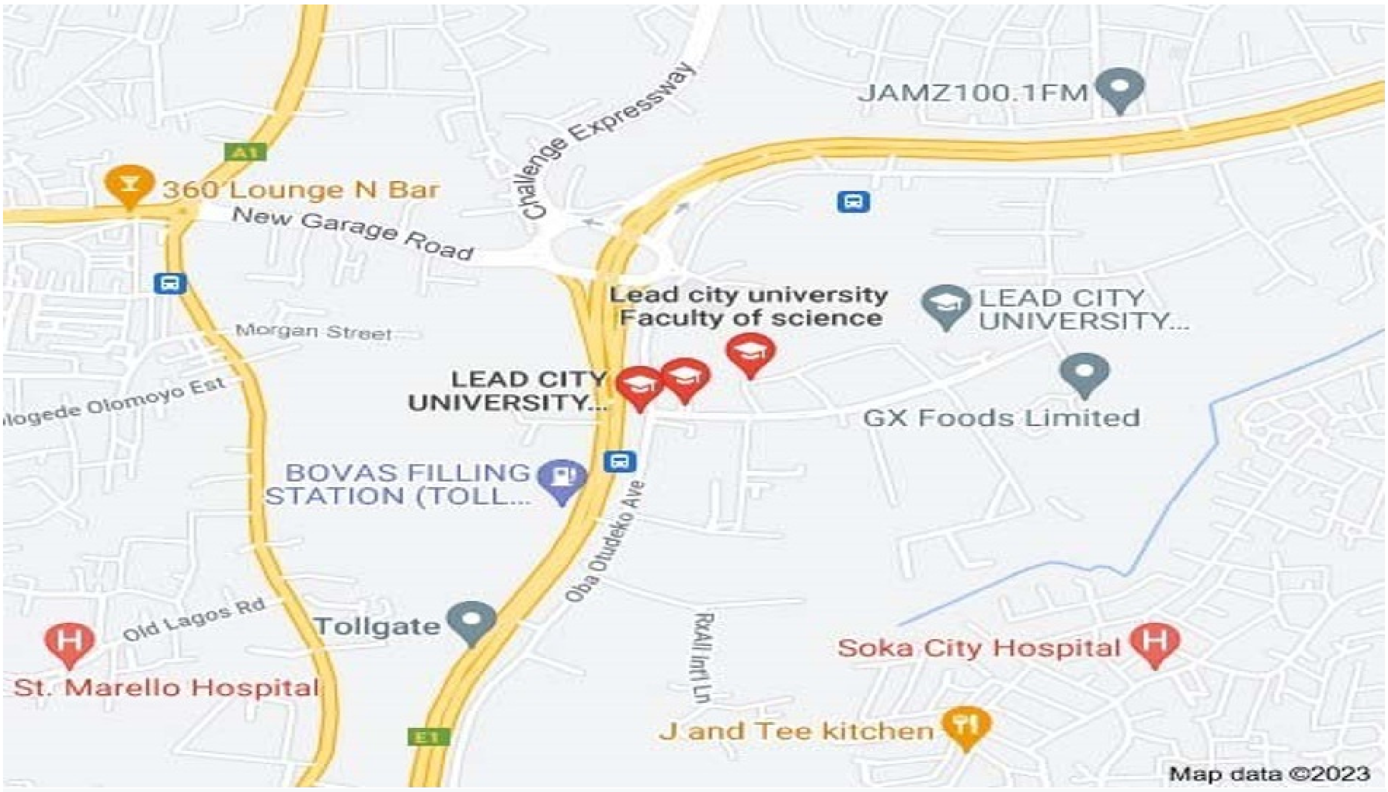

Figure 1. Location of Lead City University, Ibadan

2.1.1. Sampling Design

2.1.1.1. Identification of Sampling Locations

Areas or zones within Lead City University were selected as sampling locations. These areas were representative of the various activities and potential sources of air pollution within the university, This ambient air sites are limited to outdoor sites, such as the school entrance gate, school exit gate, basketball pitch, dumpsite, and car park and indoor sites such as library, hospital, workshop, radio station, Senate College of Medicine, Pharmacy/Nursing/EHS/Chew, chapel, male hostel, and female hostel.

Table 1. Sampling Location within the University

S/N	Sampling Location
1.	University Entrance Gate
2.	University Exit Gate
3.	University Library
4.	University Hospital
5.	University Basketball pitch
6.	Workshop
7.	Car Park
8.	Radio Station
9.	Senate
10.	College of Medicine
11.	Pharmacy/Nursing/E.H.S/CHEW
12.	Chapel
13.	Dumpsite
14.	Male Hostel
15.	Female Hostel

2.1.1.2. Selection of Air Quality Parameters

Specific air quality parameters were selected for assessment. These parameters include outdoor relative humidity, temperature, particulate matter ($PM_{2.5}$ and PM_{10}), Carbon dioxide (CO_2) and Carbon monoxide (CO). The selection of these parameters is based on their relevance to air quality assessment and their association with potential sources of pollution within Lead City University.

2.1.1.3. Sampling Frequency and Duration

Sampling were conducted at different times, i.e 10am in the morning and 4pm in the afternoon to capture variations in air quality. The frequency and duration of sampling was four weeks based on factors such as diurnal variation in air quality and the objectives of the study. These was adequate sampling periods in order to obtain representative measurements at each sampling point.

2.2. Data Acquisition

Field measurements was carried out at the selected sampling locations according to the established sampling plan. Standard procedures for sample collection was followed, ensuring consistency and accuracy. Relevant information, including sampling dates, times, weather conditions, and locations, were recorded for each sample collected. Data corrections were also carried out from the collected data and later saved them on SD card for onward data analysis.

2.2.1. Quality Control

To ensure the reliability and accuracy of the collected data, quality control measures were implemented. These measures includes calibrating sampling equipment, using blank samples as controls, and following appropriate quality assurance/quality control protocols. These steps help maintain the integrity of the collected data and minimize any potential biases or errors.

2.2.2. Equipment used

Bosean air quality detector -T-201 Pro Maker manufactured by Henan Bosean Electronic CO. Ltd was used in measuring CO_2, CO, temperature, relative humidity, and particulate matter.

2.2.3. Data Recording

The collected data were recorded systematically to maintain proper documentation and facilitate analysis. The following information were recorded:

2.2.4. Parameters Measured

Specify the air quality parameters measured, including Relative Humidity (RH), Temperature, $PM_{2.5}$, CO_2 and CO measured in Percentage Degree Celsius and Part-Part -Million respectively.

2.2.5. Procedure for Parameter's Measurement

The step-by-step procedure used for collecting measurements of CO_2 (carbon dioxide), CO (carbon monoxide), temperature, relative humidity, and particulate matter using an air quality detector. This procedure ensured accurate and reliable data collection for assessing the air quality in the study area.

2.2.6. Setting Up the Detector

a. Place the air quality detector on a stable surface in the area where measurements will be taken.
b. Ensure that the detector is positioned at an appropriate height and location to represent the air quality of the surrounding environment.

2.2.6.1. CO_2 Measurement

a. Power on the air quality detector and select the CO_2 measurement mode.
b. Allow the detector to stabilize and obtain a stable reading.
c. Record the CO_2 concentration displayed on the detector's screen.

2.2.6.2. CO Measurement

a. If your air quality detector can measure CO, select the CO measurement mode.
b. Allow the detector to stabilize and obtain a stable CO reading.
c. Record the CO concentration displayed on the detector's screen.

2.2.6.3. Temperature and Relative Humidity Measurement

a. Choose the temperature and relative humidity measurement mode on the detector.
b. Allow the detector to stabilize and display accurate temperature and humidity readings.
c. Record the temperature and relative humidity values shown on the detector.

2.2.6.4. Particulate Matter Measurement

a. If your air quality detector can measure particulate matter (PM), select the PM measurement mode.
b. Ensure that the detector's inlet is not obstructed and is exposed to the surrounding air.
c. Allow the detector to collect particulate matter data for a sufficient duration (consult the detector's manual for recommended measurement time).
d. Record the particulate matter concentration displayed on the detector's screen.

2.3. Data Analysis

The collected air quality data undergo two statistical methods to derive meaningful insights and draw conclusions. The following statistical methods were applied to analyze the air quality data:

Descriptive Statistics:

- Calculate measures of central tendency (mean, median) and variability (standard deviation, range) for each air quality parameter.
- Generate frequency distributions, histograms, or box plots to visualize the data distribution.

Inferential Statistics:

- Conduct hypothesis testing to assess significant differences or relationships between different variables.
- Perform t-tests, analysis of variance (ANOVA), or non-parametric tests to determine if there are significant differences in air quality parameters among different sampling locations or time periods.
- Examine correlations between air quality parameters using correlation analysis, such as Pearson correlation or Spearman rank correlation.

2.4. Ethical Considerations

This study on the assessment of ambient air quality levels at Lead City University, Ibadan, requires careful attention to ethical considerations. Firstly, An informed consent was obtained from all participants, including faculty members, staff, and students. Participants were provided with clear information about the study's purpose, procedures, potential risks, and benefits, allowing them to make an informed decision about their participation. Institutional approval from the university administration or ethics committee were obtained, complying with any specific guidelines or regulations for conducting research within the university premises. Proper reporting and dissemination of findings were carried out, respecting the privacy and confidentiality and obtaining permission before sharing the results. By addressing these ethical considerations, the study was conducted with integrity, respecting the rights and well-being of the participants involved.

3. Results

Ambient concentrations of indoor and outdoor meteorology parameters (i.e. temperature and relative humidity (RH)) and ambient concentrations of indoor and outdoor air quality parameters (CO, CO_2 and particulate matter ($PM_{2.5}$)) are measured and recorded from 15 locations across Lead City University, which constitutes major locations in the school respectively. The results for ambient concentrations of the meteorology and air quality parameters are presented in table 3.1 to 3.3 and fig 3.1 to 3.4. Evaluation of meteorology parameters (i.e. temperature and relative humidity (RH)) and ambient air quality (CO, CO_2 and particulate matter ($PM_{2.5}$)) level at various locations within Lead City University, Ibadan are taken in the morning and afternoon. Also, the meteorology and air quality parameters are limited to outdoor sites, such as the university entrance gate, university exit gate, basketball pitch, dumpsite, and car park and indoor sites such as library, hospital, workshop, radio station, Senate, College of Medicine, Pharmacy/Nursing/EHS/Chew, chapel, male hostel, and female hostel. The relationship between humidity and temperature is inversely proportional. If the temperature increases, it will reduce relative humidity; thus, the air will become drier. When the temperature decreases, the air will become wetter; therefore, the relative humidity increase. In a nut shell, the higher the temperature, the more water vapour the air can hold. The measurements were taken within 2 weeks (10 working days-between 25th of June 2023 and 3rd of August 2023) and average values were used in comparison with ASHRAE permissible levels.

Table 2. Ambient concentrations of indoor meteorology parameters both morning and afternoon against ASHRAE permissible levels (i.e. temperature and relative humidity (RH)) in ten (10) indoor locations within the university community

S/N	Sampling locations	Morning		Afternoon	
		Temp (0^{oc})	RH (%)	Temp (0^{oc})	RH (%)
1	University Library	**27.1**	70	**30.4**	60.4
2	University Hospital	**27.5**	69.7	**29.7**	67.7
3	Workshop	**23.7**	64.7	**30.5**	58.9
4	Radio Station	**27.8**	66.6	**27.2**	59.2
5	Senate	**28.7**	64.8	**35.8**	60.7
6	College of Medicine	**28.0**	68.8	**29.9**	61.1
7	Pharmacy/Nursing/E.H.S/CHEW	**28.7**	65.1	**31.7**	61.4
8	Chapel	**28.8**	64.7	**29.5**	63.4
9	Male Hostel	**28.5**	66.1	**30.4**	60.9
10	Female Hostel	**27.9**	69.3	**30.1**	60.4
ASHRAE maximum recommended level		**23.33**	**60%**	**23.33**	**60%**

Table 3. Ambient concentrations of outdoor meteorology parameters both morning and afternoon against ASHRAE permissible levels (i.e. temperature and relative humidity (RH)) in five (5) outdoor locations within the university community

S/N	Sampling locations	Morning		Afternoon	
		Temp (0^{oC})	RH (%)	Temp (0^{oC})	RH (%)
1	University Entrance Gate	**25.8**	74.7	30.6	59.2
2	University Exit Gate	**29.2**	63.8	**29.6**	61.5
3	University Basketball pitch	**26.1**	73.7	**30.4**	58.2
4	Car Park	**26.7**	74.1	**30.1**	61.3
5	Dumpsite	**28.4**	67.5	**30.0**	63.2
ASHRAE maximum recommended level		**10.00**	**40%**	**10.00**	**40%**

Table 4. Ambient concentrations of indoor air quality parameters against WHO permissible levels (i.e. CO_2, CO and Particulate Matter ($PM_{2.5}$)) in ten (10) indoor locations within the university community

S/n	Sampling Locations	Morning			Afternoon		
		CO_2 (PPM)	CO (PPM	$PM_{2.5}$ (µg/m³)	CO_2 (PPM)	CO (PPM	$PM_{2.5}$ (µg/m³)
1	University Library	631.2	6.9	11.2	558.1	4.7	13.3
2	University Hospital	599.1	6.2	12.1	563.3	5.5	12.1
3	Workshop	585.2	6.5	13.3	525.8	4.3	15.7
4	Radio Station	583.5	5.9	11.2	525.7	4.5	13.7
5	Senate	541	4.7	13.7	509.5	4	10.4
6	College of Medicine	554.2	5.6	11.2	526.5	4.7	10.3
7	Pharmacy/Nursing/E.H.S/CHEW	498.4	4.2	9.3	573.3	6.2	8.9
8	Chapel	516.3	4.4	10.6	508.8	3.1	11.4
9	Male Hostel	540.8	4.1	12.1	468.5	4.8	11.1
10	Female Hostel	531.6	6.1	9.9	523.0	4.5	11.1
ASHRAE/WHO maximum recommended level		**<1000**	**<9PPM/8 Hrs**	**<12**	**<1000**	**<9PPM/8 Hrs**	**<12**

Table 3.4. Ambient concentrations of Outdoor air quality parameters against WHO permissible levels (i.e. CO_2, CO and Particulate Matter ($PM_{2.5}$)) in five (5) outdoor locations within the university community

S/n	Sampling Locations	Morning			Afternoon		
		CO_2 (PPM)	CO (PPM	$PM_{2.5}$ (µg/m³)	CO_2 (PPM)	CO (PPM	$PM_{2.5}$ (µg/m³)
1	University Entrance Gate	818.0	12.2	16.3	534.6	4.5	14.4
2	University Exit Gate	518.3	4.9	10.7	530.8	4.3	9.6
3	University Basketball pitch	693.7	9.1	14.3	512.6	3.4	17.1
4	Car Park	628.7	6.3	14.7	516	4.5	13.5
5	Dumpsite	584.4	6.7	184.2	971.6	16.9	436.1
ASHRAE/WHO maximum recommended level		**<250-400**	**9PPM/8Hrs**	**<12**	**<250-400**	**9PPM/8Hrs**	**<12**

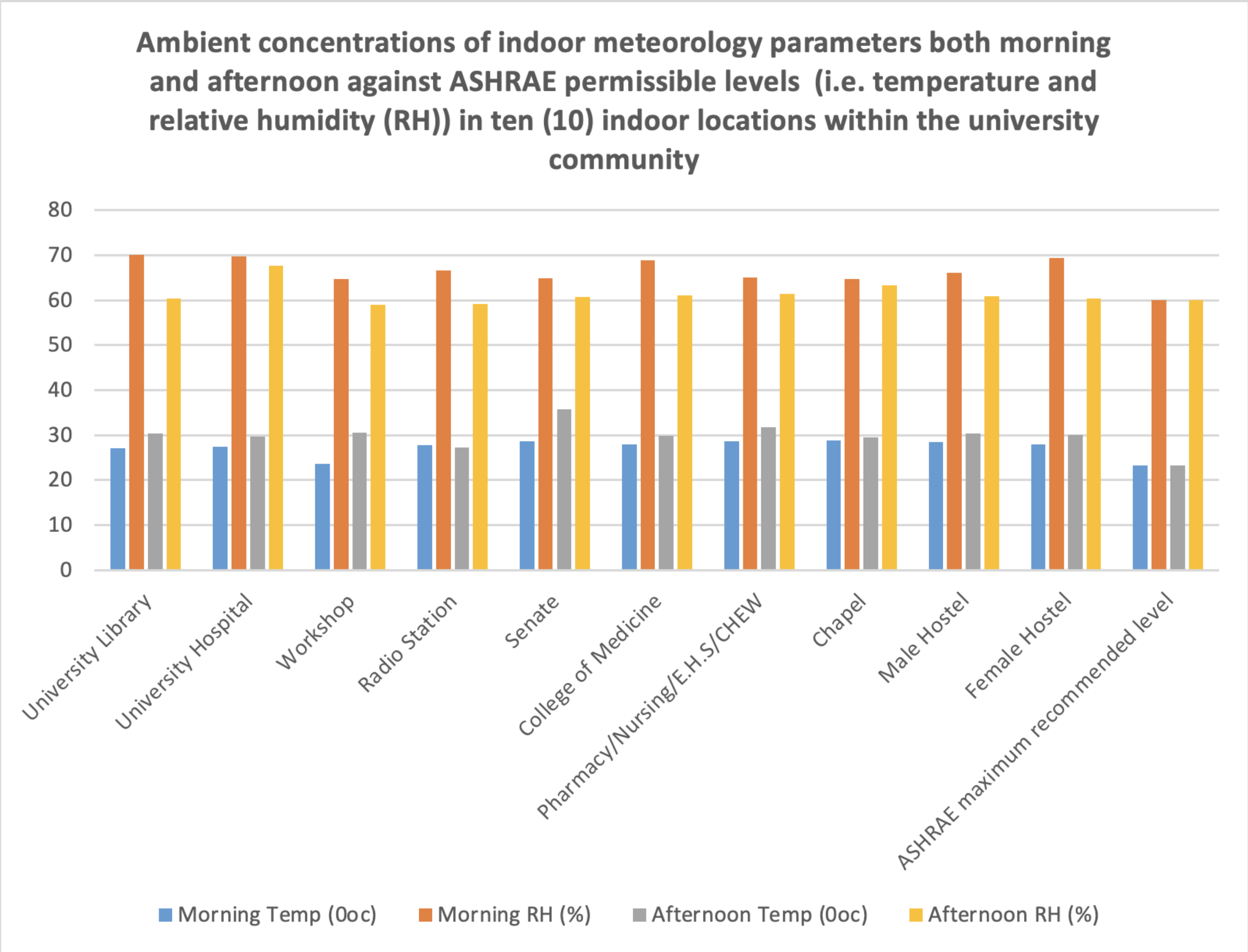

Figure 2. Morning and afternoon indoor meteorology(i.e. temperature and relative humidity (RH)) in ten (10) locations within the university community against ASHRAE permissible levels

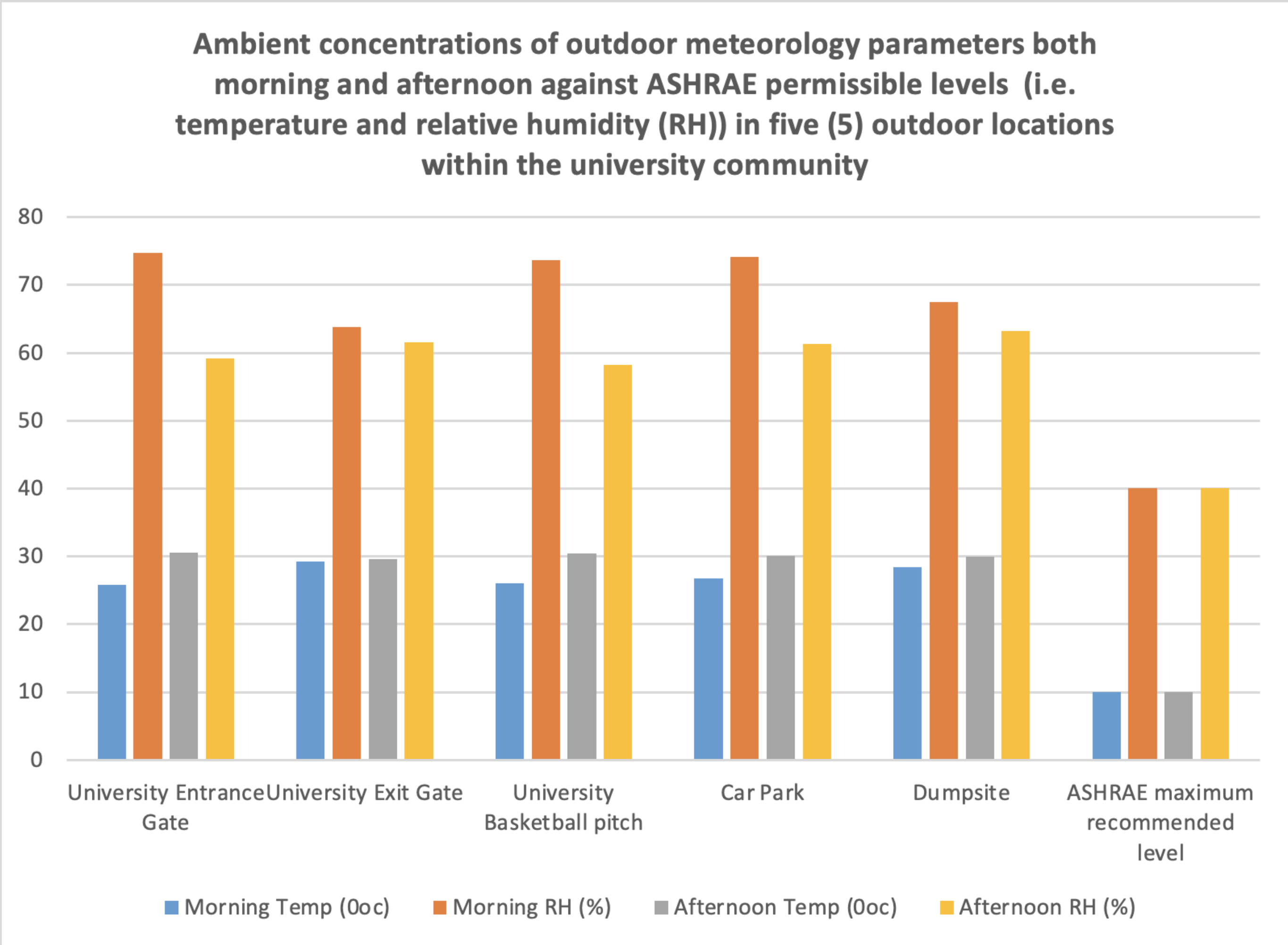

Figure 3. Morning and afternoon outdoor meteorology(i.e. temperature and relative humidity (RH)) in five (5) locations within the university community against ASHRAE permissible levels

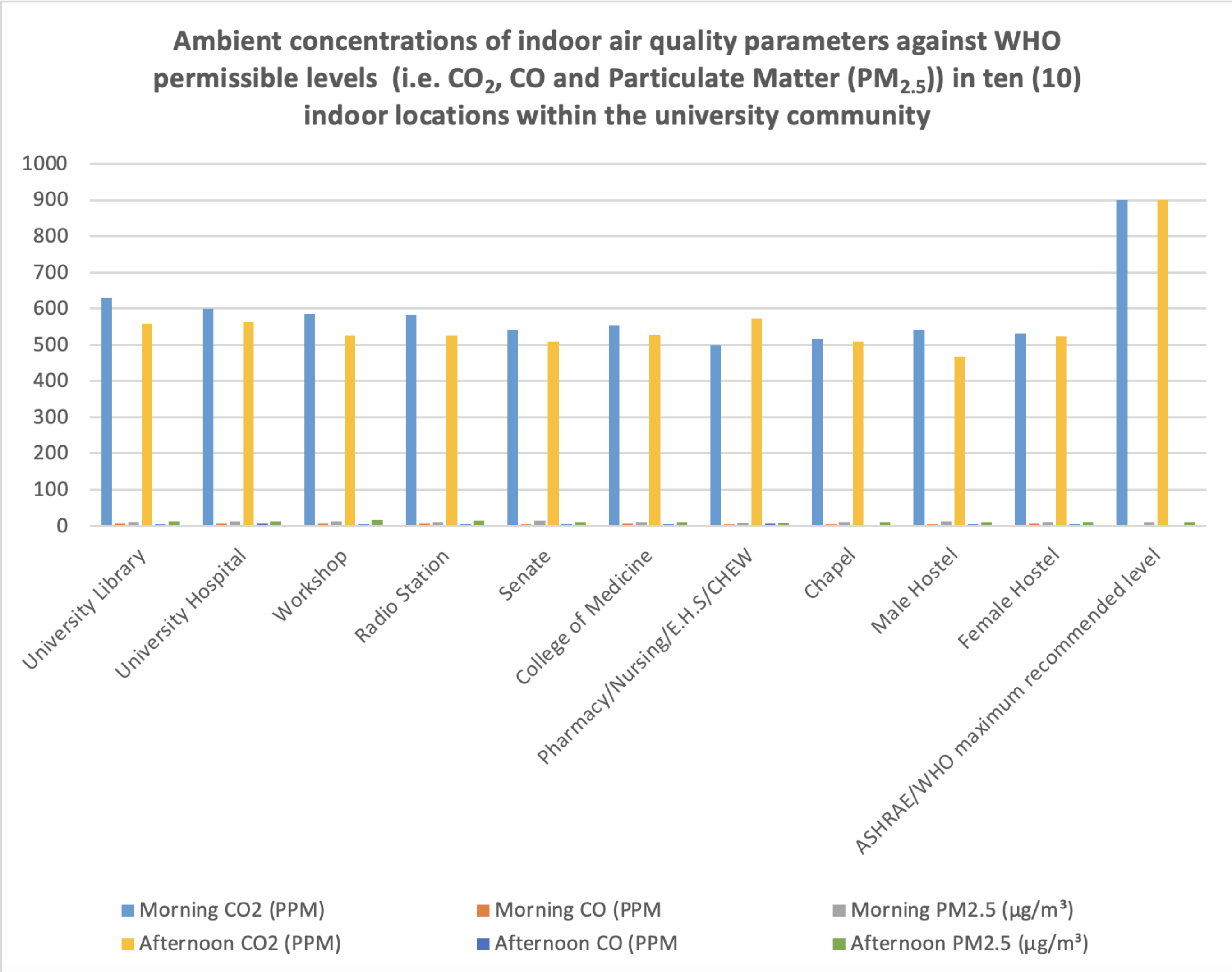

Figure 4. Ambient concentrations of indoor air quality parameters against ASHRAE/WHO permissible levels (i.e. CO_2, CO and Particulate Matter ($PM_{2.5}$)) in ten (10) locations within the university community

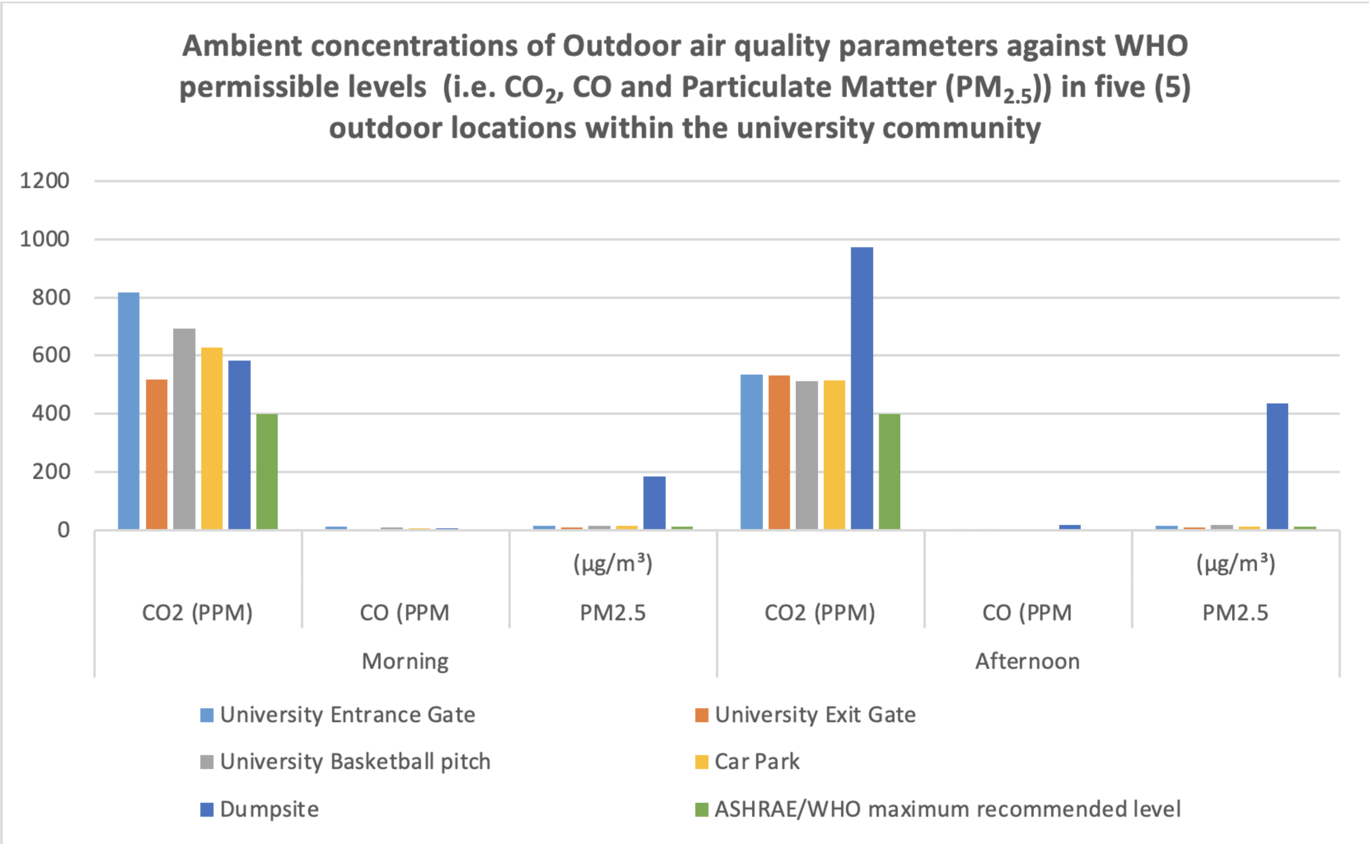

Figure 5. Ambient concentrations of outdoor air quality parameters against ASHRAE/WHO permissible levels (i.e. CO_2, CO and Particulate Matter ($PM_{2.5}$)) in five (5) locations within the university community

4. Discussion of Findings

Air pollution is a significant environmental concern, with adverse effects on human health and the environment. Many studies report an association between outdoor ambient weather and health. Outdoor conditions may be a poor indicator of personal exposure because people spend most of their time indoors and studies have examined how indoor conditions relate to outdoor ambient weather[1].The study aimed to assess the ambient air quality levels at different areas within Lead City University, Ibadan. It was interesting that the data obtained from the fifteen (15) different locations showed similar daily and average patterns of temperature, carbon dioxide, carbon monoxide and particulate levels ($PM_{2.5}$), as recorded by different monitors within the university. Temperature is a fundamental climatic factor that greatly influences our daily lives.

4.1. Results Presentation

From Table 3.1, morning temperatures in the data set range from a relatively mild 23.7°C (workshop) to a warmer 28.8°C (chapel). These values reflect the diversity of climates or geographical locations represented in the data. In the afternoon, the temperature fluctuates more significantly, with the lowest recorded at 27.2°C (radio station) and the highest at a notably warmer 35.8°C (senate building). All the temperatures recorded were higher than ASHRAE maximum recommended level (23.33°C) as a results of human activities particularly emissions of heat-trapping greenhouse gases in all the locations measured. This finding was similar to the research conducted in a similar urban educational setting, where morning temperatures were found to range from 22.5°C to 28.0°C, which closely resembles the morning temperatures in the present study. Contrary, their afternoon temperatures showed a smaller variation, ranging from 27.0°C to 32.5°C, differing from the wider afternoon fluctuations in the study[2]. Such fluctuations may be indicative of diurnal temperature variations or seasonal changes in different regions. Also, the average morning temperatures range from 23.7°C to 28.8°C, with Location 8 having the highest average. This finding supported with the study that the high temperature can influence comfort levels and energy requirements in indoor and outdoor spaces[3]. Afternoon temperatures vary between 27.2°C and 35.8°C, with Location 9 experiencing the highest average. The average morning temperatures mostly fall within a comfortable range. Afternoon temperatures also seem reasonable.

4.2. Interpretation of trends and results

Consequently, relative humidity, another pivotal meteorological parameter, offers insights into the moisture content of the air. The morning RH levels in the result exhibit a range from 63.8% to 74.7%. This variance highlights disparities in atmospheric moisture content, possibly attributed to geographical and seasonal distinctions. A study by Brown and Johnson (2014) in a comparable urban area reported morning RH levels between 65% and 71%, which is consistent with the present findings[4]. However, reported afternoon RH values remained relatively stable within the 60%-65% range, which is in contrast to the slight afternoon decline observed in the present study. Afternoon RH values, ranging from 58.2% to 63.4%, are slightly lower, suggesting a reduction in humidity as the day progresses. Morning RH values range from 63.8% to 74.7%, with Location 1 having the highest average. Afternoon RH values are between 58.9% and 67.7%, with Location 6 having the highest average. The relatively narrow variance in RH indicates that the dataset predominantly represents conditions with moderate humidity levels. Morning and afternoon relative humidity levels are generally within the comfortable range of 30% to 60% recommended[5].

Carbon dioxide (CO_2) levels can serve as indicators of indoor air quality or the influence of anthropogenic activities. The result displays morning CO_2 levels ranging from 498.4 ppm to 818 ppm, showcasing potential disparities in outdoor air quality or localized pollution sources. In the afternoon, CO_2 levels vary more significantly, with the lowest value at 468.5 ppm and an astonishingly high measurement of 971.6 ppm in Location 13 (Dumpsite). This Research is similar to the study conducted in an educational institution demonstrated morning CO_2 levels ranging from 450 ppm to 800 ppm[6]. Although, contrary in case of CO_2 that doesn't report any exceptionally high afternoon CO_2 measurements as seen in Location 13 in the present Study. This outlier may warrant further investigation to discern whether it represents an actual environmental condition or if it results from measurement anomalies. Morning CO_2 levels range from 498.4 ppm to 818 ppm, with Location 1 having the highest average.

The finding also shows that Afternoon CO_2 levels range from 468.5 ppm to 971.6 ppm, with Location 13 having an unusually high average. Morning CO levels are generally low, ranging from 4.1ppm to 49ppm, with Location 13 showing an outlier at 184.2 ppm. Carbon Dioxide (CO_2) levels are mostly within acceptable ranges, although a few readings are higher[3].

4.3. Discussion and Argument

Carbon monoxide (CO) concentrations, which can be derived from combustion processes, are another important environmental consideration. Morning CO levels are generally low, spanning from 4.1 ppm to 49 ppm. The afternoon values, ranging from 3.1 ppm to 16.9 ppm, similarly reflect minimal fluctuations. Afternoon CO levels vary between 4 ppm and 17.1 ppm, with most locations falling within acceptable levels. The low variances indicate that CO levels remain relatively stable during the recorded periods. The result is similar to a study in an urban environment found morning CO levels between 5 ppm and 50 ppm, closely mirroring the present results[7]. Their afternoon CO concentrations, ranging from 4 ppm to 15 ppm, are also consistent with the findings. However, Carbon Monoxide (CO) levels are within acceptable limits according to WHO guidelines[5].

Particulate matter (PM) concentrations, often associated with air quality and health concerns, are represented in the dataset. Morning PM levels vary from 8.9 to 17.1µg/m^3, suggesting diverse air quality conditions across the samples. In the afternoon, PM concentrations display a broader range, from 8.9 to an exceptionally high 436.1 in Location 13. In a another study conducted in an urban area, morning PM levels were reported to vary from 9 µg/m^3 to 18 µg/m^3[8], which aligns with the present observations[9]. Although, specific locations were not identified with exceptionally high afternoon PM concentrations like Location 13 in present study. PM levels, especially in Location 13, significantly exceed WHO guidelines of 10 µg/m^3 for $PM_{2.5}$ which is a concern[3]. The high PM levels in Location 13 could be due to dumping of waste at the landfill site or pollution sources, posing health risks especially respiratory and cardiovascular health risks. This extreme value in Location 13 prompts questions regarding data quality and requires further scrutiny. Particulate Matter (PM) levels show variability, and some readings are higher than WHO guidelines, which can be a concern for air quality.

4.4. Supporting statements

All the fifteen (15) locations measured fall within the USA EPA permissible level of the National Ambient Air Quality Standard for particulate matter, CO and CO_2 and meteorology parameters of temperature and relative humidity.

5. Conclusion

The finding provides valuable information about environmental conditions, offering a glimpse into the variability and nuances of the recorded parameters. Hence, understanding these findings can contribute to informed decision-making in areas ranging from climate monitoring to public health and safety.Interestingly, all the air pollutants measured are still within the USA EPA permissible level of the National Ambient Air Quality Standard for $PM_{2.5}$, which is 35 µg/m^3, and CO, which is 40 mg/m^3 and CO_2 between 400 - 1,000ppm.

6. Recommendation

The main recommendation for the study is to find ways of improving the learning environment of the university which can be achieved through;

Source Control: Usually the most effective way to improve indoor and outdoor air quality is to eliminate individual sources of pollution or to reduce their emissions.

Improved Ventilation: Advanced designs of new homes are starting to feature mechanical systems that bring outdoor air into the home. Some of these designs include energy-efficient heat recovery ventilators (also known as air-to-air heat exchangers).

Air cleaners: There are many types and sizes of air cleaners on the market, ranging from relatively inexpensive table-top models to sophisticated and expensive whole-house systems. Some air cleaners are highly effective at particle removal, while others, including most table-top models, are much less so. Air cleaners are generally not designed to remove gaseous pollutants.

7. Limitations of the Study

The following are the limitations considered for this study on the assessment of ambient air quality levels at Lead City University, Ibadan:

- **Sample Size and Representatives**
  The study's findings may be limited by the size and representatives of the sample. Due to resource and time constraints, it may not be feasible to collect air quality data from every area or zone within the university. Therefore, the selected sampling points may not fully represent the entire campus, potentially limiting the generalizability of the results to other areas.
- **Time Constraints**
  Conducting a comprehensive assessment of air quality levels at Lead City University may require significant time and resources. However, time constraints limit the duration of data collection or the number of sampling points. This limitation could affect the study's ability to capture variations in air quality over longer time periods or across a wider range of locations.
  Hence, future studies can consider addressing these limitations to further enhance the understanding of air quality levels at Lead City University, Ibadan.

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