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

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Abstract

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 overestimate how much air pollution affects the health and happiness of students. Based on this, evaluation of ambient air quality (i.e., temperature, relative humidity (RH), CO_2, and particulate matter ($PM_{2.5}$)) at various locations within Lead City University, Ibadan, is essential.

Ambient concentrations of carbon monoxide (CO), carbon dioxide (CO_2), relative humidity (RH), temperature (TEMP), and particulate matter (PM) were recorded from 15 locations across Lead City University over a two-week period. Morning temperatures in all the locations measured ranged from 23.7°C to 29.2°C, while afternoon temperatures fluctuated 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 ranged from 63.8% to 74.7%, while afternoon RH values ranged from 58.2% to 63.4%. The findings also show 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 ranged from 4.1 µg/m³ to 49 µg/m³, with location 13 showing an outlier at 184.2 µg/m³. CO2 and CO levels are mostly within acceptable ranges.

Conclusively, variability in these parameters has implications for human health; therefore, adequate ventilation and pollution control measures are 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. e tal (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. 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), nitrogen dioxide (NO2), sulfur dioxide (SO2), carbon monoxide (CO), ozone (O3), lead (Pb), and volatile organic compounds (VOCs). These pollutants can come from both natural and human-made sources, such as industrial emissions, vehicular traffic, and the burning of fossil fuels (Oguntoke, O. et al. (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_2) is a toxic gas that can cause headaches, dizziness, and nausea. It is produced by the incomplete combustion of fossil fuels, such as in vehicles and generators. Ozone is a reactive gas that can cause respiratory problems and aggravate asthma. It is formed when nitrogen oxides and volatile organic compounds (VOCs) react in the presence of sunlight.

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 air quality data through monitoring stations and the establishment of air quality standards and guidelines by regulatory agencies. These standards and guidelines help to 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.

1.1. Main Objective

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

1.2. Specific Objectives

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 matter ($PM_{2.5}$ & PM_{10}), 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.

1.3. Research Questions

1. What are the concentrations of humidity (indoor and outdoor), carbon dioxide, carbon monoxide, temperature (indoor and outdoor), and particulate matter ($PM_{2.5}$) 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. How do the concentrations of air pollutants measured within Lead City University, Ibadan, compare to national and international air quality standards and action levels?
4. What are the levels and sources of air pollutants based on the analysis of data collected from air quality monitoring equipment?
5. What recommendations can be made for effective air quality management strategies based on the findings of the study?

1.4. Scope of the Study

The scope of this study is to assess the ambient air quality levels at different areas within Lead City University, Ibadan. 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 generalizable to other universities or locations in Nigeria.

Hence, the scope of this study is to assess the ambient air quality levels at different areas within Lead City University, Ibadan. The study will investigate the levels and sources of air pollutants and will cover different areas within the university. The study is limited to Lead City University, Ibadan, and may not be generalizable to other locations.

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. The campus encompasses various academic buildings, administrative offices, lecture halls, laboratories, libraries, and student hostels. The university offers a wide range of undergraduate and postgraduate programs across multiple disciplines, including arts, sciences, social sciences, management sciences, and engineering.

The campus is designed to provide a conducive learning environment for students. It incorporates green spaces, walkways, and recreational areas, fostering a pleasant atmosphere. The university also prioritizes the provision of modern amenities and resources to support teaching, research, and student life.

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.

2.2. Sampling Design

2.2.1. 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, such as the school entrance gate, school exit gate, library, hospital, basketball pitch, workshop, car park, radio station, Senate College of Medicine, Pharmacy/Nursing/EHS/Chew, chapel, dumpsite, male hostel, and female hostel.

2.2.2. Selection of Air Quality Parameters

Specific air quality parameters were selected for assessment. These parameters include indoor and 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.

2.2.3. Sampling Frequency and Duration

Sampling was conducted at different times (morning and afternoon) to capture variations in air quality. The frequency and duration of sampling were determined based on factors such as diurnal variation in air quality and the objectives of the study. Adequate sampling periods were established to obtain representative measurements at each sampling point.

2.2.4. Data Collection

Field measurements were carried out at the selected sampling locations according to the established sampling plan. Standard procedures for sample collection were followed, ensuring consistency and accuracy. Relevant information, including sampling dates, times, weather conditions, and locations, was recorded for each sample collected.

2.2.5. Quality Control

To ensure the reliability and accuracy of the collected data, quality control measures were implemented. These measures included 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.

2.3. Selected Air Quality Parameters

2.3.1. Relative Humidity (Outdoor)

Relative humidity is a measure of the moisture content in the air. Indoor relative humidity reflects the moisture levels within buildings, while outdoor relative humidity indicates the atmospheric moisture levels.

2.3.2. Temperature (Outdoor)

Temperature refers to the degree of hotness or coldness in the air. Indoor temperature represents the thermal conditions within buildings, while outdoor temperature reflects the ambient temperature in the surroundings.

2.3.3. Particulate Matter ($PM_{2.5}$ and PM_{10})

Particulate Matter (PM) refers to solid or liquid particles suspended in the air. $PM_{2.5}$ represents particles with a diameter of 2.5 micrometers or smaller, while PM_{10} represents particles with a diameter of 10 micrometers or smaller. These parameters are crucial for assessing air pollution and its health impacts.

2.3.4. Carbon Monoxide (CO)

Carbon monoxide is a colorless and odorless gas produced by incomplete combustion of fuels. It is primarily emitted from vehicle exhaust and can have adverse effects on human health.

2.3.5. Carbon Dioxide (CO_2)

Carbon dioxide (CO_2) is a colorless and odorless gas that is a natural component of Earth's atmosphere. It is released into the atmosphere through various natural processes, including respiration by animals and plants, volcanic activity, and the decay of organic matter. CO_2 is also a byproduct of human activities, especially the burning of fossil fuels like coal, oil, and natural gas.

2.4. Equipment used

An air quality detector was used in measuring CO_2, CO, temperature, relative humidity, and particulate matter.

2.5. Sampling Frequency and Duration

In determining the sampling frequency and duration for air sampling at each location, diurnal variations were used to capture the selected parameters for the study.

2.5.1. Diurnal Variations

Diurnal variations refer to the daily patterns of air quality parameters that occur throughout a 24-hour period. To capture these variations adequately, sampling should be conducted multiple times during a day. Consider the following:

For parameters affected by diurnal variations, such as temperature and relative humidity, samples were collected at least three times a day: morning, midday, and evening.

For parameters influenced by human activities or emissions, such as CO_2 and CO, sampling included both peak and off-peak periods. This involved conducting sampling during rush hours, business hours, or times when specific activities (e.g., construction, industrial processes) are expected to occur.

2.6. Data Recording

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

2.7. Parameters Measured

Specify the air quality parameters measured, including Relative Humidity (RH), Temperature, $PM_{2.5}$, CO_2, and CO.

2.7.1. 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.

2.7.2. Materials Required

Air quality detector (capable of measuring CO_2, CO, temperature, relative humidity, and particulate matter)

Preparation

a. Ensure that the air quality detector is properly calibrated according to the manufacturer's instructions before starting measurements.
b. Check the detector's power source or batteries to ensure they have sufficient charge.

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.

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.

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.

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.

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.

2.7.3. Post-Measurement Steps

a. Power off the air quality detector.
b. If necessary, repeat the measurements at different times or locations for a comprehensive assessment of air quality.

2.7.4. Data Analysis and Interpretation

a. Transfer the recorded data to a computer or analysis software for further analysis.
b. Compare the collected measurements with relevant air quality standards or guidelines to assess the environmental conditions.

2.7.5. Safety Precautions

a. Always follow safety guidelines while working with air quality detectors, especially if dealing with potentially hazardous environments.
b. Wear appropriate protective gear if required.

2.8. Data Sheets

- Use standardized data sheets or electronic records to enter the collected data accurately and consistently.
- Double-check the entered values for accuracy and completeness.

- Ensure the data sheets or electronic records are securely stored for future reference and analysis.

N.B: By maintaining comprehensive and well-organized records, it becomes easier to analyze the data, detect patterns or trends, and draw meaningful conclusions about the air quality levels at different areas within Lead City University, Ibadan**.**

2.8.1. Data Validation

Data validation procedures were implemented to ensure the integrity of the analysis results. Quality control data, calibration data, and instrument performance checks were reviewed to identify any outliers, inconsistencies, or potential errors. Results were validated based on established acceptance criteria and standard procedures.

2.9. 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.

2.10. Ethical Considerations

This study on the assessment of ambient air quality levels at Lead City University, Ibadan, requires careful attention to ethical considerations. Firstly, 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 was obtained, complying with any specific guidelines or regulations for conducting research within the university premises. Proper reporting and dissemination of findings was 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.

2.11. 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.

3. Results

Ambient concentrations of carbon monoxide (CO), carbon dioxide (CO_2), relative humidity (RH), temperature (TEMP), and particulate matter (PM) were recorded from 15 locations across Lead City University, which constitutes major locations in the school, respectively. The results for ambient concentrations of the pollutants are presented in table and graphical format.

3.1. Sampling Locations within the University

Table 1.

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

Table 2. Concentration of the selected Parameters in the University Gate Entrance

S/N	Morning					Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1	25	77	879	14	27	31	55	546	5	15
2	27	74	795	11	25	30	60	633	6	16
3	26	71	812	13	15	29	65	493	3	7
4	26	75	747	11	12	30	58	507	5	28
5	26	80	754	11	17	30	68	662	6	18
6	26	74	872	14	10	33	49	499	3	12
7	25	73	904	13	12	30	61	512	4	12
8	25	76	831	13	9	32	54	488	5	19
9	26	74	761	10	11	29	67	489	4	11
10	26	73	864	12	25	32	55	517	4	18
11	258	747	8189	122	163	306	5346	5346	45	144
	258/10	747/10	8189/10	122/10	163/10	306/10	592/10	5346/10	45/10	144/10
TOTAL	**25.8**	**74.7**	**818**	**12.2**	**16.3**	**30.6**	**59.2**	**534.6**	**4.5**	**14.4**

Table 3. Ambient concentration of the selected Parameters in the University Exit Gate

S/N	Morning					Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1	29	60	599	7	15	30	57	532	5	11
2	29	61	603	8	14	30	57	605	6	7
3	29	68	550	6	13	30	68	502	4	13
4	31	58	479	4	5	30	57	476	2	8
5	29	62	468	3	10	30	61	548	5	14
6	29	68	486	4	11	28	61	602	9	7
7	30	62	514	5	9	33	56	512	3	9
8	28	68	482	4	9	27	69	514	4	10
9	30	63	521	4	8	29	62	480	3	7
10	28	68	481	4	13	29	67	477	2	10
11	292	638	5183	49	107	296	615	5308	43	96
	292/10	638/10	5183/10	49/10	107/10	296/10	615/10	5308/10	43/10	96/10
TOTAL	**29.2**	**63.8**	**518.3**	**4.9**	**10.7**	**29.6**	**61.5**	**530.8**	**4.3**	**9.6**

Table 4. Ambient concentration of the selected Parameters at the University Library

S/N	Morning					Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1	28	68	599	6	12	29	59	609	7	14
2	27	61	603	8	14	30	58	568	5	14
3	26	77	760	11	15	29	64	506	4	11
4	28	67	658	7	10	30	62	502	4	15
5	28	69	594	5	8	31	62	612	3	15
6	27	73	610	5	11	32	55	623	7	8
7	27	72	641	8	9	31	58	534	6	11
8	27	69	599	5	12	31	62	475	2	19
9	26	74	620	7	11	31	56	490	3	12
10	27	70	628	7	10	30	68	662	6	14
11	271	700	6312	69	112	304	604	5581	47	133
	271/10	700/10	6312/10	69/10	112/10	304/10	604/10	5581/10	47/10	133/10
TOTAL	**27.1**	**70**	**631.2**	**6.9**	**11.2**	**30.4**	**60.4**	**558.1**	**4.7**	**13.3**

Table 5. Ambient concentration of the selected Parameters at the University Hospital

S/N	Morning					Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1	28	71	610	7	15	29	60	586	7	13
2	27	70	655	7	14	29	61	566	7	19
3	26	75	613	8	17	29	65	536	5	8
4	29	65	580	5	11	29	60	501	4	16
5	28	68	586	7	10	30	63	630	5	12
6	28	70	572	5	14	32	54	544	6	9
7	28	68	593	6	11	30	61	635	8	7
8	27	67	590	5	10	30	63	620	3	13
9	27	72	576	6	8	30	60	525	5	9
10	27	71	616	6	11	29	65	490	5	15
11	275	697	5991	62	121	297	677	5633	55	121
	275/10	697/10	5991/10	62/10	121/10	297/10	677/10	5633/10	55/10	121/10
TOTAL	**27.5**	**69.7**	**599.1**	**6.2**	**12.1**	**29.7**	**67.7**	**563.3**	**5.5**	**12.1**

Table 6. Ambient concentration of the selected Parameters at the University Basketball Pitch

S/N	Morning					Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1	26	76	700	10	14	31	55	553	4	24
2	26	75	766	11	10	30	60	623	6	20
3	26	76	717	10	12	29	66	468	2	8
4	26	72	700	9	16	30	60	495	5	27
5	26	74	659	7	19	30	60	589	3	21
6	27	74	647	9	17	32	50	508	3	11
7	26	74	671	9	12	30	59	488	4	17
8	26	69	685	9	11	33	53	476	2	21
9	26	74	714	9	13	31	56	474	2	10
10	26	73	678	8	19	28	63	452	3	12
11	261	737	6937	91	143	304	582	5126	34	171
	261/10	737/10	6937/10	91/10	143/10	304/10	582/10	5126/10	34/10	171/10
Total	**26.1**	**73.7**	**693.7**	**9.1**	**14.3**	**30.4**	**58.2**	**512.6**	**3.4**	**17.1**

Table 7. Ambient concentration of the selected Parameters at the Workshop

S/N	Morning					Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1						31	58	586	7	14
2	26	72	701	8	21	30	59	607	7	18
3	26	77	663	9	16	29	63	472	4	7
4	28	64	600	6	16	29	62	492	3	22
5	26	73	621	6	14	29	63	610	4	18
6	27	75	638	7	18	32	51	586	6	10
7	26	73	647	7	14	31	58	513	3	16
8	26	69	668	9	9	33	55	499	3	18
9	26	73	665	7	12	31	57	482	3	13
10	26	71	649	6	13	30	63	411	3	21
11	237	647	5852	65	133	305	589	5258	43	157
	237/10	647/10	5852/10	65/10	133/10	305/10	589/10	5258/10	43/10	157/10
TOTAL	**23.7**	**64.7**	**585.2**	**6.5**	**13.3**	**30.5**	**58.9**	**525.8**	**4.3**	**15.7**

Table 8. Ambient concentration of the selected Parameters in the Car park

S/N	Morning					Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1	26	70	620	6	18	29	59	586	7	13
2	26	73	677	8	18	30	58	557	5	18
3	26	77	659	7	21	29	65	420	4	6
4	28	67	642	6	11	28	64	495	3	17
5	27	72	619	7	12	31	62	485	5	16
6	27	74	609	5	16	33	53	552	5	7
7	27	72	604	7	12	30	61	522	5	10
8	27	67	587	5	9	31	60	491	4	17
9	26	71	591	5	14	30	62	502	3	13
10	27	71	619	7	16	30	69	500	4	18
11	267	714	6287	63	147	301	613	5160	45	135
	267/10	714/10	6287/10	63/10	147/10	301/10	613/10	5160/10	45/10	135/10
TOTAL	**26.7**	**71.4**	**628.7**	**6.3**	**14.7**	**30.1**	**61.3**	**516**	**4.5**	**13.5**

Table 9. Ambient concentration of the selected Parameters in the Radio Station

S/N	Morning					Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1	27	65	599	6	13	30	57	552	5	11
2	28	66	600	5	15	30	60	559	6	19
3	27	73	552	4	10	30	62	473	4	10
4	29	60	521	6	16	29	63	472	4	15
5	28	67	563	4	12	30	60	612	3	21
6	29	68	540	6	12	30	50	645	7	10
7	28	70	880	13	3	32	59	532	4	9
8	27	65	510	3	11	30	63	473	3	20
9	28	65	544	6	12	31	56	471	4	10
10	27	67	526	6	8	30	62	468	5	12
11	278	666	5835	59	112	272	592	5257	45	137
	278/10	666/10	5835/10	59/10	112/10	272/10	592/10	5257/10	45/10	137/10
TOTAL	**27.8**	**66.6**	**583.5**	**5.9**	**11.2**	**27.2**	**59.2**	**525.7**	**4.5**	**13.7**

Table 10. Ambient concentration of the selected Parameters at the Senate Building

S/N	Morning					Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1	28	65	620	5	13	29	59	508	4	10
2	28	65	616	3	14	30	58	551	5	10
3	28	68	538	6	21	29	68	525	4	14
4	31	55	507	5	5	30	59	465	3	9
5	29	68	518	5	8	29	61	486	3	9
6	28	68	498	5	11	34	55	548	6	9
7	30	65	611	6	10	32	57	557	5	9
8	28	66	494	3	9	28	66	477	3	10
9	29	63	524	4	7	29	62	495	3	8
10	28	65	484	5	39	39	62	483	4	16
11	287	648	5410	47	137	358	607	5,095	40	104
	287/10	648/10	5410/10	47/10	137/10	358/10	607/10	5095/10	40/10	104/10
Total	**28.7**	**64.8**	**541**	**4.7**	**13.7**	**35.8**	**60.7**	**509.5**	**4**	**10.4**

Table 11. Ambient concentration of the selected Parameters at the College of Medicine

S/N	Morning					Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1	29	67	590	6	15	31	58	597	8	10
2	28	68	595	7	18	32	58	540	4	12
3	26	76	580	6	19	29	65	483	3	8
4	29	64	509	5	9	30	59	462	4	10
5	28	69	523	5	9	30	61	559	6	10
6	29	67	507	4	8	33	50	551	4	8
7	29	70	683	9	10	29	63	556	5	10
8	26	72	531	4	9	29	66	481	5	19
9	28	69	510	5	8	28	66	524	5	6
10	28	66	514	5	7	28	65	512	3	10
11	280	688	5542	56	112	299	611	5265	47	103
	280/10	688/10	5542/10	56/10	112/10	299/10	611/10	5265/10	47/10	103/10
TOTAL	**28**	**68.8**	**554.2**	**5.6**	**11.2**	**29.9**	**61.1**	**526.5**	**4.7**	**10.3**

Table 12. Ambient concentration of the selected Parameters at Pharm/Nursing/EHS Dept.

S/N	Morning					Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1	29	68	529	4	10	30	62	537	4	10
2	27	67	530	5	12	33	53	874	13	12
3	29	67	493	3	10	29	69	504	3	11
4	30	59	472	4	4	29	63	481	3	9
5	29	63	472	2	8	25	55	803	12	2
6	29	66	488	5	12	26	56	68	10	8
7	30	62	497	5	9	32	55	498	4	8
8	27	68	501	5	8	26	72	566	7	9
9	30	63	520	5	8	29	61	459	3	8
10	27	68	482	4	12	29	68	487	3	12
11	287	651	4984	42	93	317	614	5733	62	89
	287/10	651/10	4984/10	42/10	93/10	317/10	614/10	5733/10	62/10	89/10
TOTAL	**28.7**	**65.1**	**498.4**	**4.2**	**9.3**	**31.7**	**61.4**	**573.3**	**6.2**	**8.9**

Table 13. Ambient concentration of the selected Parameters at the University Chapel

S/N	Morning					Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1	29	65	520	5	10	30	57	539	5	9
2	28	62	533	4	17	30	57	567	5	12
3	29	66	526	6	13	28	70	483	3	14
4	29	55	465	3	4	29	61	464	2	9
5	29	64	478	5	9	29	69	476	2	8
6	29	69	499	5	12	29	66	555	4	14
7	30	66	590	5	6	32	57	573	5	11
8	28	67	481	4	10	28	68	486	3	13
9	29	67	487	4	8	30	60	466	4	9
10	28	66	584	3	17	30	69	479	2	15
11	288	647	5163	44	106	295	634	5088	31	114
	288/10	647/10	5163/10	44/10	106/10	295/10	634/10	5088/10	31/10	114/10
TOTAL	**28.8**	**64.7**	**516.3**	**4.4**	**10.6**	**29.5**	**63.4**	**508.8**	**3.1**	**11.4**

Table 14. Ambient concentration of the selected Parameters at the Dumpsite

S/N	Morning					Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1	28	67	620	8	20	31	59	956	18	999
2	27	69	621	9	999	31	59	1979	42	999
3	29	68	553	6	19	30	64	536	5	10
4	29	62	539	6	7	28	65	583	7	856
5	28	68	513	3	9	29	66	590	6	82
6	29	69	516	4	9	30	61	522	5	12
7	29	67	671	9	379	30	63	662	7	179
8	29	67	673	12	243	30	65	510	4	189
9	28	69	544	5	38	31	61	263	64	999
10	28	69	594	5	119	30	69	698	9	36
11	284	675	5844	67	1842	300	632	9716	169	4361
	284/10	675/10	5844/10	67/10	1842/10	300/10	632/10	9716/10	169/10	4361/10
TOTAL	**28.4**	**67.5**	**584.4**	**6.7**	**184.2**	**30**	**63.2**	**971.6**	**16.9**	**436.1**

Table 15. Ambient concentration of the selected Parameters at the Male Hostel

S/N	Morning					Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1	28	65	570	4	15	31	54	607	7	13
2	28	64	573	5	14	31	59	528	6	13
3	28	66	484	3	17	30	61	474	4	11
4	30	57	469	4	5	28	66	447	2	9
5	28	71	525	4	7	30	68	581	3	12
6	28	69	525	3	8	33	59	595	6	8
7	29	68	583	7	10	30	61	518	3	9
8	29	68	593	3	10	30	61	453	4	13
9	29	66	522	4	22	32	55	541	6	7
10	28	67	564	4	13	29	65	482	7	16
11	285	661	5408	41	121	304	609	4685	48	111
	285/10	661/10	5408/10	41/10	121/10	304/10	609/10	4685/10	48/10	111/10
TOTAL	**28.5**	**66.1**	**540.8**	**4.1**	**12.1**	**30.4**	**60.9**	**468.5**	**4.8**	**11.1**

Table 16. Ambient concentration of the selected Parameters at the Female Hostel

S/N	Morning					Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1	29	69	609	6	11	30	59	591	6	13
2	27	70	627	6	12	30	60	547	4	12
3	27	74	577	5	9	30	63	496	4	7
4	29	65	608	8	7	30	61	483	3	13
5	27	70	563	5	12	29	69	501	4	19
6	28	73	582	7	11	33	54	657	6	6
7	28	70	589	5	9	30	60	524	4	9
8	28	66	569	6	10	31	62	544	6	13
9	28	69	609	6	9	30	61	487	4	8
10	28	67	572	7	9	28	55	420	4	11
11	279	693	5316	61	99	301	604	5230	45	111
	279/10	693/10	5316/10	61/10	99/10	301/10	604/10	5230/10	45/10	111/10
TOTAL	**27.9**	**69.3**	**531.6**	**6.1**	**9.9**	**30.1**	**60.4**	**523.0**	**4.5**	**11.1**

Table 17. Average Ambient concentration of Temp, CO2, CO, PM and RH for Morning and Afternoon

Sampling Location	Average Morning					Average Afternoon				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1.	25.8	74.7	818	12.2	16.3	30.6	59.2	534.6	4.5	14.4
2.	29.2	63.8	518.3	49	10.7	29.6	61.5	530.8	4.3	9.6
3.	27.1	70	631.2	6.9	11.2	30.4	60.4	558.1	4.7	13.3
4.	27.5	69.7	599.1	6.2	12.1	29.7	67.7	563.3	5.5	12.1
5.	26.1	73.7	693.7	9.1	14.3	30.4	58.2	512.6	3.4	17.1
6.	23.7	64.7	585.2	6.5	13.3	30.5	58.9	525.8	4.8	15.7
7.	26.7	71.4	628.7	6.3	14.3	30.1	61.3	516	4.5	13.5
8.	27.8	66.6	583.5	5.9	11.2	27.2	59.2	525.7	4.5	13.7
9.	28.9	64.8	541	4.7	13.7	35.8	60.7	509.5	4.0	10.4
10.	28	68.8	554.2	5.6	11.2	29.9	61.1	526.5	4.7	10.3
11.	28.7	65.1	498.4	4.2	9.3	31.7	61.4	573.3	6.2	8.9
12.	28.8	64.7	516.3	4.4	10.6	29.5	63.4	508.8	3.1	11.4
13.	28.4	67.5	584.4	6.7	184.2	30.0	63.2	971.6	16.9	436.1
14.	28.5	66.1	540.8	4.1	12.1	30.4	60.9	468.5	4.8	11.1
15.	27.9	69.3	531.6	6.1	9.9	30.1	60.4	523	4.5	11.1

Table 18. Showing Variance for concentration of Temp, CO2, CO, PM and RH for Morning and Afternoon

Sampling Location	Average Morning (Variance)					Average Afternoon (Variance)				
	TEMP	RH	CO_2	CO	PM	TEMP	RH	CO_2	CO	PM
1.	4.6	14.59	82163.17	23.13	186.48	0.98	12.13	4250.23	1.45	5.59
2.	5.18	35.83	21613.97	1707.70	12.83	0.13	16.52	2221.03	1.66	3.40
3.	1.63	35.70	27679.00	6.45	4.99	0.00	9.15	3167.14	1.96	0.36
4.	0.94	15.49	17085.73	5.32	2.69	0.04	32.43	1479.67	1.48	0.04
5.	1.98	28.25	1026	4.00	5.53	5.18	0.01	16.89	5122.23	0.85
6.	5.01	78.29	15442.47	2.17	2.07	0.03	12.39	4784.20	0.66	3.74
7.	0.79	43.02	12592.87	3.21	0.25	0.09	17.07	3537.57	0.21	0.38
8.	0.77	49.43	17486.63	0.49	0.62	4.38	17.28	2971.57	0.16	0.17
9.	5.01	46.34	18683.60	0.64	9.63	39.78	26.32	12647.57	0.09	10.81
10.	0.44	25.56	7912.63	0.08	0.62	0.06	29.34	1195.37	0.16	0.17
11.	0.31	8.25	3763.90	0.44	0.81	0.41	35.09	7758.93	2.15	0.09
12.	0.01	9.64	2036.37	0.29	0.88	0.11	18.86	5396.23	0.03	0.25
13.	0.07	22.44	7796.30	4.18	6765	4.38	0.00	4286.13	6.47	66565.86
14.	0.21	1.97	4655.60	0.09	0.28	0.08	18.81	1943.83	0.19	0.21
15.	0.92	27.50	2842.40	0.17	2.29	0.01	10.68	5080.90	0.06	2.50

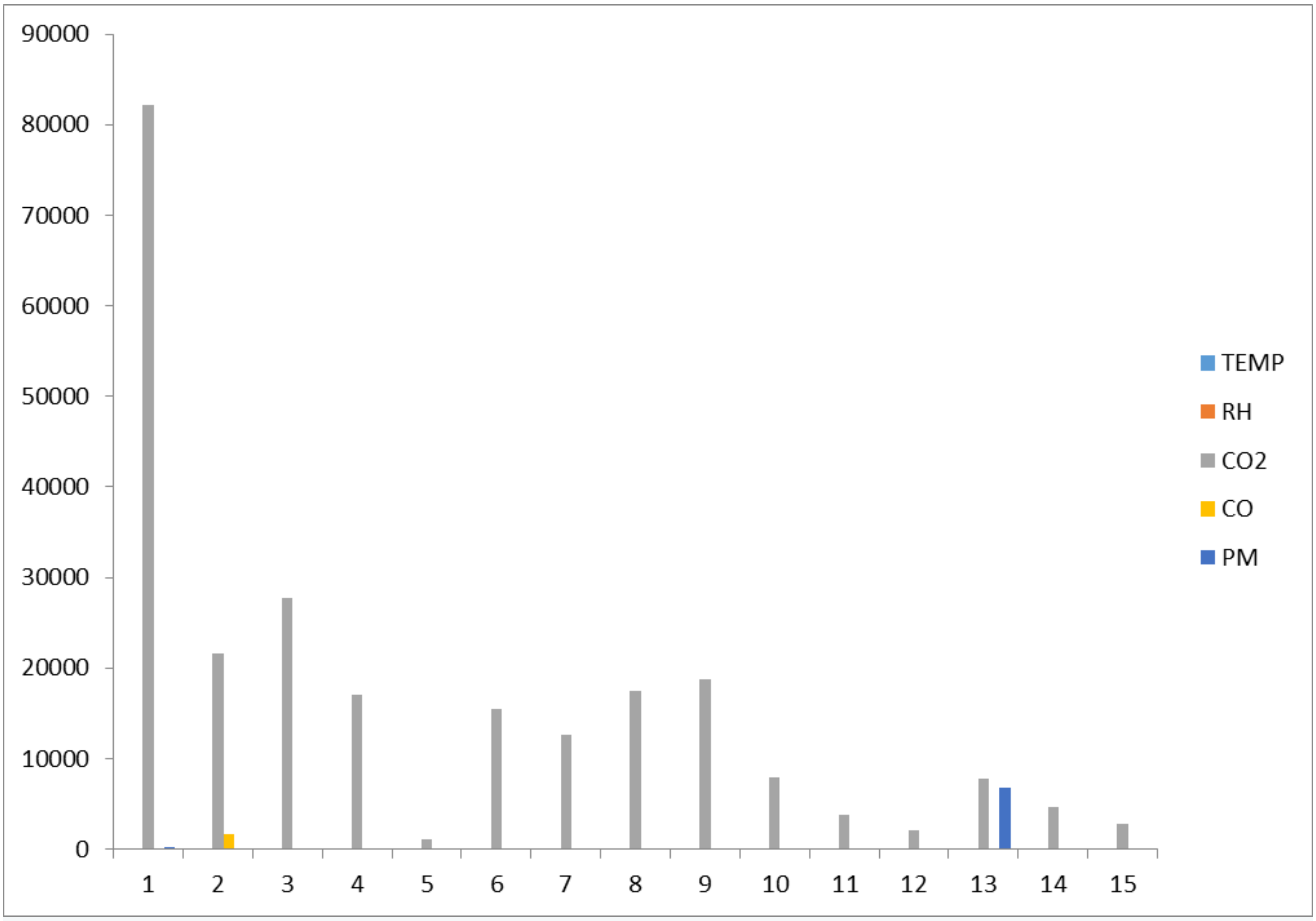

Figure 1. Concentration of Temp, CO2, CO, PM and RH for Morning (Variance)

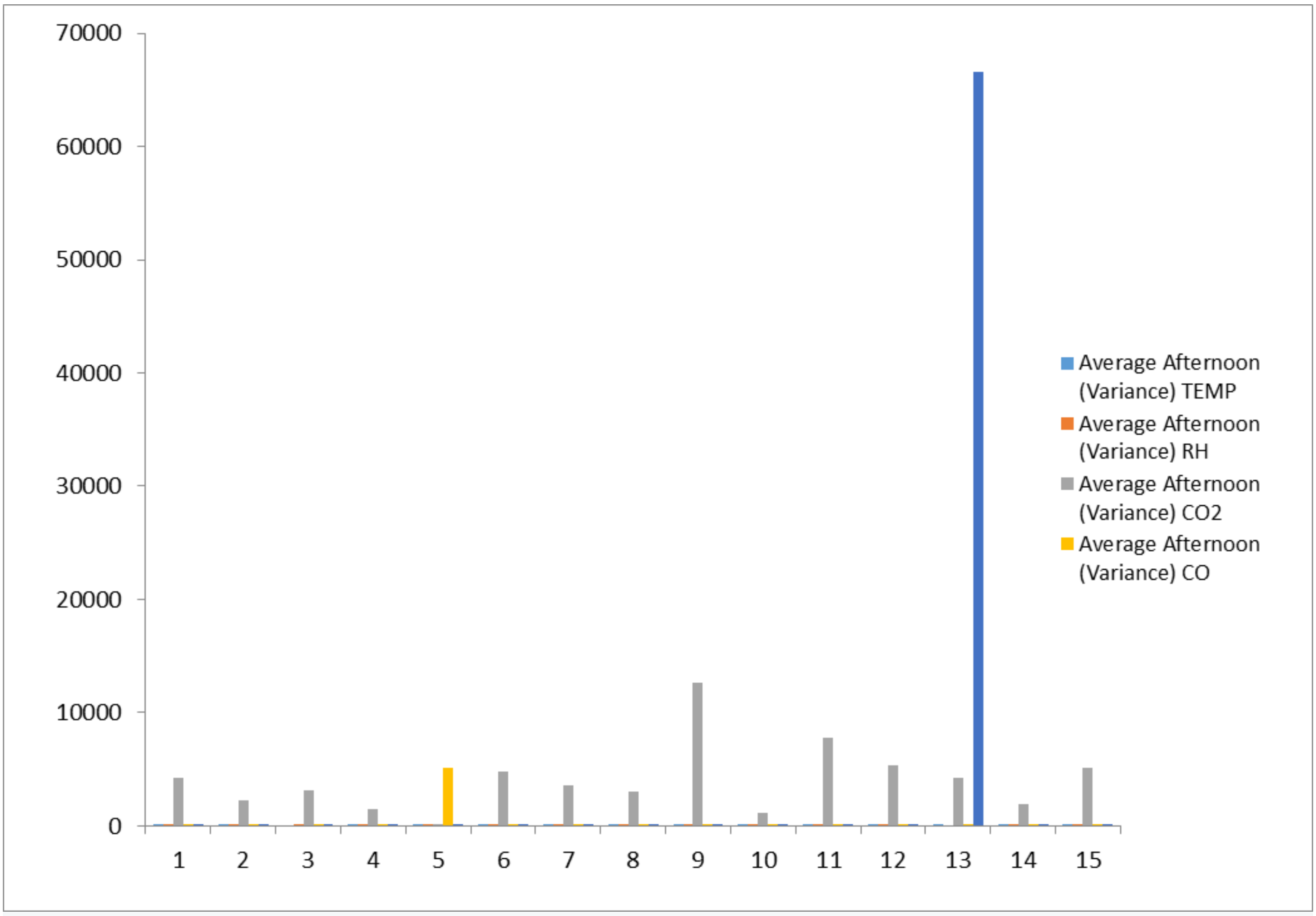

Figure 2. Variability of Temp, CO2, CO, PM and RH for Afternoon

4. Summary of Findings and Conclusion

Air pollution is a significant environmental concern, with adverse effects on human health and the environment. The study aimed to assess the ambient air quality levels at different areas within Lead City University, Ibadan. Temperature is a fundamental climatic factor that greatly influences our daily lives. From Table 16, morning temperatures in the data set range from a relatively mild 23.7°C to a warmer 29.2°C. 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 and the highest at a notably warmer 35.8°C. This finding is similar to the research conducted (Smith, J. et al (2017)), and in a similar urban educational setting, morning temperatures were found to range from 22.5°C to 28.0°C, which closely resembles the morning temperatures in the present study. Contrarily, 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. Such fluctuations may be indicative of diurnal temperature variations or seasonal changes in different regions. The average morning temperatures range from 23.7°C to 29.2°C, with Location 2 having the highest average. This finding is supported by the study that suggests high temperatures can influence comfort levels and energy requirements in indoor and outdoor spaces[2]. 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.

Consequently, relative humidity, another pivotal meteorological parameter, offers insights into the moisture content of the air. The morning RH levels in the results 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 in a comparable urban area reported morning RH levels between 65% and 71%, which is consistent with the present findings (Brown, R., & Johnson, B. (2014)). 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 by the WHO (World Health Organization (WHO) 2021).

Carbon dioxide (CO_2) levels can serve as indicators of indoor air quality or the influence of anthropogenic activities. The results display 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 by Green and Williams in an educational institution, which demonstrated morning CO_2 levels ranging from 450 ppm to 800 ppm. Although contrary in the 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 4.1 µg/m³ to 49 µg/m³, with Location 13 showing an outlier at 184.2 µg/m³. Carbon Dioxide (CO_2) levels are mostly within acceptable ranges, although a few readings are higher (ASHRAE Standard 55-2020).

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 µg/m³ and 17.1 µg/m³, 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 that found morning CO levels between 5 ppm and 50 ppm, closely mirroring the present results (Black, M., White, P., & Gray, G. (2019). 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 (World Health Organization (WHO) 2021).

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/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. In a study by Kumar & Dash in an urban area, morning PM levels were reported to vary from 9 μg/m³ to 18 μg/m³, which aligns with the present observations (Sahu, V., & Gurjar, B. R. (2020). Although specific locations were not identified with exceptionally high afternoon PM concentrations like Location 13 in the present study, PM levels, especially in Location 13, significantly exceed WHO guidelines of 10 μg/m³ for PM2.5, which is a concern (ASHRAE Standard 55-2020). The high PM levels in Location 13 could be due to industrial activity 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.

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.

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