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Research Article

Assessment of the Indoor Air Quality (IAQ) in Lead City University Classrooms and Offices

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Abstract

Indoor Air Quality (IAQ), particularly in educational facilities, is gaining considerable interest and is a synonymous indicator towards evaluating human comfort. Factors such as CO2 concentration, temperature, and humidity play crucial parts in determining an acceptable level of IAQ. Many studies have also demonstrated that the indoor air quality of classrooms affects students' concentration and performance.

The research utilized both objective measurements and subjective surveys. Air temperature, CO2 levels and humidity were measured by hand-handling Bosean Air Quality detector in Lead City University, Ibadan. Temperature, Carbon dioxide, carbon monoxide, humidity and particulate matter (PM2.5), air quality index (AQI), TVCO and HCHO measurements were conducted over two weeks' period and the minimum and maximum temperature over 10 continuous days for each learning environment were recorded. Temperature and RH levels generally fall within the permissible levels recommended by the WHO which contributed to the conducive living environment. Carbon dioxide and Carbon monoxide levels in most locations are also within the permissible levels with little location that deviated and need monitoring. Therefore, through investigation is needed is needed in all the locations that are higher than the WHO recommended values.

Keywords: Indoor Air Quality (IAQ), Temperature, Carbon dioxide, Carbon monoxide, Particulate Matter, Relative Humidity, TVO, HCHO and Lead City University (LCU)

Introduction

Air pollution is now a serious worldwide public health problem. Developmental activities like industrial expansion, mining exploration, transportation and constructional works etc. cause degradation and drastic changes in every component of environment. Air pollution has emerged in the past few decades as the most crucial problem to mankind and many studies in this regard have been undertaken in all over the World [1]. Indoor workspaces refer to areas within a building where people carry out work-related activities. These spaces may include offices, meeting rooms, laboratories, manufacturing facilities, and other work environments that are enclosed and not exposed to the outdoor environment. The quality of indoor air in these workspaces can have a significant impact on the health, comfort, and productivity of the occupants. [2]. Air pollution and its detrimental health impacts have become a major global environmental and health concern, and the mitigation of air pollution is a primary focus of policymakers. Many air pollutants are extremely detrimental to health. Rapid population growth, increase in vehicular traffic, urban expansion and the burning of solid biomass fuel are considered some of the main factors contributing to poor air quality in Africa [3,4].

Insufficient quality of the indoor environment for the learning purpose can prevent students and teachers from progressing in their learning process. Students' attention may stray away from learning goals due to the influence of the internal environment and its determining parameters. The indoor environment is defined by several partial elements – thermal and humidity parameters, ventilation, lighting, acoustics, odours, and microbial, aerosol and ionization factor [5]. The parameters of Indoor Air Quality (IAQ) influence not only health but also the ability to learn and work. The results of the studies show that in the case of full occupancy of the classrooms, the indoor air quality deteriorates rapidly. The concentration of Carbon dioxide (CO_2) in the classrooms is rapidly rising [6]. Other independent studies demonstrate the effect of internal quality on performance and productivity [7-9]. The quality of the internal environment in schools also influences the student-perceived social climate [10].

The importance of indoor air quality has become increasingly recognized in recent years, with numerous studies highlighting its impact on health and productivity. For example, a study by 5 found that improved indoor air quality was associated with significant improvements in cognitive function, including decision-making and problem-solving skills [11]

In addition to its impact on human health and productivity, indoor air quality is also a significant concern from an environmental perspective. The use of energy-intensive Heating, Ventilation, And Air Conditioning (HVAC) systems to regulate indoor air temperature and quality can contribute to greenhouse gas emissions and climate change [12]. The quality of the internal environment in schools also influences the student-perceived social climate [13,14].

The scope of study is to assess the Indoor Air Quality of classrooms in Lead City University by monitoring indoor air parameters (temperature, relative humidity, carbon monoxide, carbon dioxide, ozone, total volatile organic compounds in different classrooms.

This study when completed will benefit

1. **Occupants of indoor workspaces**: The study can benefit the occupants of indoor workspaces by providing a healthier and more comfortable environment, which can lead to improved well-being, reduced sick leave, and increased job satisfaction.
2. **Future researcher**: This research work will provide literature for references for future researches.

Aim and Objectives of the Study

The general objective of the study is to examine the indoor air quality in Lead City University Classrooms and Offices. While the specific objectives of the study are:

1. To measure Indoor Air Quality (IAQ) in Lead City University classrooms
2. To compare the level of measured indoor air quality of Lead City University classrooms with World Health Organization (WHO) permissible levels of indoor air quality.
3. To proffer solution to the problem of indoor air quality pollution in Lead City University, Ibadan

Research Question

1. What are the different levels of Indoor Air Quality (IAQ) in Lead City University, Ibadan classrooms?
2. Is the measured Indoor Air Quality (IAQ) in Lead City University classrooms below or above the World Health Organization (WHO) permissible levels indoor air quality?
3. What are the solutions to the problem of indoor air quality pollution in Lead City University, Ibadan?

Table 1: Classroom locations selected in Lead City University, Ibadan.

S/N	Classrooms	Locations
1	NUR/EHS/CHEW	Classroom
2	Library	Reading Room
3	Clinic	Waiting Room
4	Law Theatre	Classroom
5	Faculty of Social Science	Classroom
6	Faculty of Pharmacy	Classroom
7	College of Medicine	Classroom
8	Senate Building	Waiting Room
9	Block C	Classroom
10	Faculty of Natural and Applied Science	Classroom

Materials and Methods

Ten (10) classrooms (1-10) are selected in Lead City University, Ibadan to investigate the university's indoor environment. One of the tested university classes is block C (9). The walls and ceilings are fitted with a classic internal plaster with white paint. Flooring is PVC linoleum. The windows are new, plastic with a shading system of internal blinds. The classroom equipment is classical and includes tables, chairs and whiteboard. The survey was conducted during July 2023. The climate in Lead City University during July is cool and reasonably dry. Daytime maximum temperatures average around a cool 23, while at night 13°C is normal. Below is the classroom's location used in the research work (Table 1).

This research would utilize both objective measurements and subjective surveys. Air temperature, CO_2 levels and humidity would be measured and analyzed as an indicator for IAQ. The objectives datasets were collected using three different types of data loggers, namely: an internal Tinytag temperature and humidity data logger, an internal Tinytag CO_2 data logger, and an external temperature and humidity data logger. In order to capture and distinguish changes of indoor environment, the data collection of this study was carried out before, during and after students' classes over two-week period. The data loggers were connected to power outlets and placed at 1.2m above the floor (average human sitting height) and would be in operation for the entire one-week duration. Other possible impact factors, such as the area of the monitored learning environment, the number of occupants, and the facilities within the rooms (such as computers) were also be recorded (the room volume and the activities being carried out can also affect the levels of CO_2 and humidity, which may ultimately affect human comfort.

The university building investigated for this study is Lead City University, Ibadan, Oyo state; and represents a typical Higher Educational building across the country, Nigeria. Different types of learning spaces were selected within the University building, 10 in total as indicated in (Table 1) above. This also helped diversify the data, identify level of comfort in various rooms and also provided an opportunity to identify the effect of equipment in a room on user comfort. The level of installed ventilation (mechanical or natural) in support of health and safety guidelines were also be put into consideration. The objective measurements were compared to a permissible levels stipulated by World Health Organization (WHO) The survey were conducted the same time as the experimental measurements so as to analyze changes in IAQ perception over the duration of the classes.

Data Instruments and Collection

The indoor air temperature, relative humidity and carbon dioxide (CO_2) concentration in the 10 selected learning spaces were measured by using HOBO U12-012 data loggers (temperature range-20; relative humidity ranges 5% - 95% ± 2.5%) and CARBOCAP CO_2 monitors (measuring range 0-5000 ppm; accuracy±2% of range ± 2% of reading). The CO_2 monitor was connected to a HOBO data logger via an external cable. All the devices were calibrated prior to the readings and the data would be recorded in 5minutes intervals.

Temperature Measurement: Temperature measurements were conducted over two weeks' period and the minimum and maximum temperature over 10 continuous days for each learning environment were recorded.

Carbon Dioxide Measurement: The minimum and maximum CO_2 levels across the 10 rooms over 10 continuous days were recorded.

Humidity Measurement: The relative humidity percentages were recorded within the 10 surveyed rooms over 10 days.

Table 2: Air Quality Measurements at NUR/EHS/CHEW.

Day 1 Monday	Morning Parameters									Afternoon Parameters								
Locations	TEMP 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	REMARKS	TEMP. 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	REMARKS
1	-	-	-	-	-	-	-	-		27	61	6	0.032	5	596	0.645	26	
2	27	67	6	0.038	4	526	0.468	19		27	58	5	0.065	9	677	0.939	30	
3	28	68	4	0.041	5	526	0.468	18		28	72	8	0.03	7	576	0.59	24	
4	30	57	5	0.023	4	481	0.281	11		27	62	7	0.05	4	475	0.255	12	
5	28	67	4	0.031	5	491	0.323	13		26	70	8	0.026	5	485	0.279	11	
6	28	70	12	0.047	3	493	0.314	13		25	54	1	0.161	10	797	1.34	40	
7	30	63	7	0.037	4	512	0.392	15		31	63	3	0.05	8	648	0.836	28	
8	28	67	6	0.036	5	527	0.442	18		26	72	8	0.028	8	644	0.798	28	
9	29	64	6	0.058	6	591	0.599	56		28	65	5	0.027	3	486	0.309	13	
10	28	64	9	0.031	4	476	0.261	11		29	69	11	0.026	2	477	0.258	10	
Total	256	587	59	0.338	40	4,683	3.568	174		274	646	62	0.495	61	5,881	6.249	222	

-:-	10	10	10	10	10	10	10	10	-:-	10	10	10	10	10	10	10	10	
Average	25.6	58.7	5.9	0.0338	4	468.3	0.3568	17.4		27.4	64.6	6.2	0.0495	6.1	586.1	0.6249	22.2	

Inclusion Criteria

Eligible locations were classrooms selected in Lead City University, Ibadan.

Exclusion Criteria

Outdoor spaces were excluded from this study.

Data Entry and Analysis

Data collected were analyzed with the aid of the computer software: Statistical Package for Social Sciences (SPSS) Version 20. Relevant means were calculated.

Results and Discussion of Findings

This chapter presents air quality measured at different locations in the university in order to assess the Indoor Air Quality (IAQ) in Lead City University Classrooms and Office.

Discussion of Findings

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 classroom within Lead City University, Ibadan. Temperature is a fundamental climatic factor that greatly influences our daily lives. From (Table 2), morning temperatures in the dataset range from a relatively mild 27°C to a warmer 28°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°C and the highest at a notably warmer 29°C. Such fluctuations may be indicative of diurnal temperature variations or seasonal changes in different regions. The average morning temperatures range from 24.2°C to 25.6°C, with Location 4 having the highest average (26°C). This finding supported with the study that the high temperature can influence comfort levels and energy requirements in indoor and outdoor spaces1,4. Afternoon temperatures vary between 27.4°C and 27.7°C, with Location 2 and 9 (30.2°C) 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 result exhibit a range from 58.7% to 64.4%. This variance highlights disparities in atmospheric moisture content, possibly attributed to geographical and seasonal distinctions. Afternoon RH values, ranging from 41% to 64.6%, are slightly lower, suggesting a reduction in humidity as the day progresses. Morning RH values range from 58.7% to 64.4%, with Location 9 having the highest average (64.4%). Afternoon RH values are between 41% and 64.6%, with Location 4 having the highest average (82.9%). 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 WHO [15].

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 468.3ppm to 565.5ppm, 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 586.1ppm and an astonishingly high measurement of 542ppm in Location 3 (621.6ppm). Carbon monoxide (CO) concentrations, which can be derived from combustion processes, are another important environmental consideration. Morning CO levels are generally low, spanning from 4ppm to 6.4 ppm. The low variances indicate that CO levels remain relatively stable during the recorded periods. Carbon Monoxide (CO) levels are within acceptable limits according to WHO guidelines.

Particulate Matter (PM) concentrations, often associated with air quality and health concerns, are represented in the dataset. Morning PM levels vary from 5.7 to 7μg/m^3, suggesting diverse air quality conditions across the samples. In the afternoon, PM concentrations display a broader range, from 6.2 to 12.8μg/m^3. The high PM levels in Location 6 (12.8μg/m^3,) could be due to industrial activity or pollution sources, posing health risks especially respiratory and cardiovascular health risks. 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 (Tables 3-12, Figures 1-22).

Table 3: Air Quality Measurements at University Library.

Day 2 TUES-DAY	Morning Parameters									Afternoon Parameters								
Loca-tions	TEMP. 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	RE-MARKS	TEMP. 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	RE-MARKS
1	-	-	-	-	-	-	-	-		30	59	9	0.062	8	636	0.849	29	
2	27	72	7	0.055	9	724	1.151	35		30	60	5	0.042	7	588	0.696	26	
3	26	72	6	0.055	8	687	0.971	31		30	63	4	0.033	6	546	0.401	19	
4	27	66	9	0.036	8	640	0.803	28		29	65	9	0.067	6	534	0.455	18	
5	28	70	4	0.043	6	639	0.786	28		31	62	13	0.02	2	467	0.24	11	
6	28	73	5	0.05	7	586	0.611	25		33	54	5	0.055	7	612	0.709	27	
7	27	71	3	1.402	9	713	1.402	32		31	60	4	0.035	6	571	0.573	23	
8	27	67	5	0.04	4	566	0.542	21		30	61	2	0.016	3	471	0.231	12	
9	26	74	8	0.052	7	640	0.798	28		30	58	6	0.04	4	514	0.393	16	
10	27	71	5	0.042	7	642	0.833	29		28	59	5	0.051	7	614	0.241	20	
Total	243	636	52	1.27	65	5,937	7.897	257		302	601	72	0.421	56	5,553	4.788	201	
-:-	10	10	10	10	10	10	10	10	-:-	10	10	10	10	10	10	10	10	
Aver-age	24.3	63.6	5.2	0.127	6.5	583.7	0.7897	25.7		30.2	60.1	7.2	0.0421	5.6	555.3	0.4788	20.1	

Table 4: Air Quality Measurements at University Clinic.

Day 3 Wed nes day	Morning Parameters									Afternoon Parameters								
Loca-tions	TE MP.	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	RE MAR KS	TE MP.	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	REMA RKS
	0C									0C								
	-	-	-	-	-	-	-	-		29	58	9	0.085	6	584	0.725	29	
	27	70	6	0.053	9	667	0.91	29		29	60	8	0.028	6	565	0.597	21	
	27	74	7	0.076	8	656	0.898	30		29	65	8	0.24	6	546	0.401	19	
	29	65	5	0.173	10	695	0.979	42		29	61	13	0.152	4	550	0.576	40	
	27	69	5	0.04	7	599	0.658	26		31	64	8	0.146	8	652	0.855	36	
	28	72	5	0.048	5	586	0.611	25		33	54	6	0.296	9	746	1.138	75	
	28	69	5	1.368	11	785	1.347	80		30	61	8	0.252	9	674	1.072	58	
	27	69	7	0.416	12	847	1.538	78		31	63	8	0.136	6	599	0.818	35	
	28	72	7	0.133	11	738	1.154	34		30	60	8	0.148	5	555	0.558	40	
	27	71	5	0.208	9	752	1.19	54		30	63	6	0.13	9	745	1.636	71	
	248	631	52	2.515	82	6,325	9.285	398		301	609	82	1.613	68	6,216	8.359	424	
-:-	10	10	10	10	10	10	10	10	-:-	10	10	10	10	10	10	10	10	
	24.8	63.1	5.2	0.2515	8.2	632.5	0.9285	39.8		30.1	60.9	8.2	0.1613	6.8	621.6	0.8359	42.4	

Table 5: Air Quality Measurements at Law Theatre.

Day 4 Thurs-day	**Morning Parameters**									**Afternoon Parameters**								
Loca-tions	TEMP.	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	RE MAR KS	TEMP.	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	RE MA RKS
	0C									0C								
1	-	-	-	-	-	-	-	-		29	59	10	0.023	5	525	0.42	17	
2	28	62	14	0.038	6	523	0.422	17		30	59	11	0.033	6	547	0.45	18	
3	29	66	13	0.032	6	525	0.438	17		29	68	5	0.04	3	493	0.343	14	
4	30	57	5	0.032	4	477	0.268	11		28	60	9	0.03	4	475	0.262	11	
5	29	64	8	0.027	3	476	0.265	11		28	66	5	0.042	4	496	0.347	15	
6	29	68	9	0.047	4	503	0.346	14		28	64	13	0.18	5	590	0.587	80	
7	30	65	7	0.036	5	562	0.552	22		33	55	9	0.032	4	500	0.338	14	
8	28	67	8	0.033	5	489	0.301	12		27	69	6	0.025	4	496	0.342	14	
9	29	66	6	0.03	4	496	0.316	13		29	60	5	0.025	5	483	0.281	12	
10	28	67	8	0.043	4	499	0.348	14		30	69	11	0.023	5	488	0.295	12	
Total	260	582	78	0.318	41	4,550	3.256	131		291	629	84	0.453	46	5,093	3.665	207	
-:-	10	10	10	10	10	10	10	10	-:-	10	10	10	10	10	10	10	10	
Aver-age	26	58.2	7.8	0.0318	4.1	455	0.3256	13.1		29.1	62.9	8.4	0.0453	4.6	509.3	0.3665	20.7	

Table 6: Air Quality Measurements at Faculty of Pharmacy.

Day 5 Fri-day	**Morning Parameters**									**Afternoon Parameters**								
Loca-tions	TEMP.	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	RE MAR KS	TEMP.	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	RE MA RKS
	0C									0C								
1	-	-	-	-	-	-	-	-		27	63	13	0.035	3	520	0.395	17	
2	27	64	15	0.03	9	614	0.704	46		32	54	6	0.058	10	686	0.984	31	
3	28	67	14	0.033	5	506	0.361	14		28	69	11	0.042	5	520	0.41	17	
4	29	59	5	0.026	4	478	0.259	10		30	58	3	0.041	3	506	0.382	15	
5	29	64	5	0.033	5	484	0.285	12		25	68	6	0.047	8	640	0.608	25	
6	29	69	10	0.048	5	496	0.322	13		25	53	2	0.153	9	668	1.24	30	
7	30	62	7	0.03	4	507	0.352	15		33	54	13	0.011	3	512	0.388	15	
8	27	67	5	0.041	3	495	0.317	13		27	69	6	0.031	5	543	0.486	20	
9	30	61	6	0.051	3	521	0.409	17		28	62	3	0.046	7	570	0.577	24	
10	28	63	6	0.036	5	485	0.3	12		29	68	9	0.025	4	473	0.252	10	
Total	257	576	73	0.328	43	4586	3.309	152		284	618	72	0.489	57	5,698	5.722	204	
-:-	10	10	10	10	10	10	10	10	-:-	10	10	10	10	10	10	10	10	
Aver-age	25.7	57.6	7.3	0.0328	4.3	458.6	0.3309	15.2		28.4	61.8	7.2	0.0489	5.7	569.8	0.5722	20.4	

Table 7: Air Quality Measurements at Faculty of Social Science.

Day 6 Mon-day	Morning Parameters										Afternoon Parameters								
SEN-ATE	TEMP. 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	RE MA RKS	SEN-ATE	TEMP. 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	RE MA RKS
DAY 1	-	-	-	-	-	-	-	-		DAY 1	29	59	11	0.018	6	525	0.404	16	
DAY 2	26	71	6	0.043	9	667	0.891	30		DAY 2	30	59	7	0.032	8	636	0.774	28	
DAY 3	27	75	7	0.04	8	631	0.78	28		DAY 3	30	65	6	0.038	3	520	0.406	17	
DAY 4	28	64	4	0.042	5	603	0.675	20		DAY 4	29	63	8	0.032	5	579	0.408	16	
DAY 5	27	72	9	0.053	4	560	0.55	22		DAY 5	29	65	7	0.036	4	529	0.434	18	
DAY 6	29	69	9	0.063	6	535	0.448	19		DAY 6	32	56	2	0.128	10	776	1.266	36	
DAY 7	28	73	1	0.313	14	881	1.632	72		DAY 7	30	61	6	0.032	7	505	0.562	23	
DAY 8	29	69	4	0.037	5	570	0.574	23		DAY 8	29	66	7	0.036	4	529	0.436	18	
DAY 9	27	69	8	0.045	5	528	0.426	17		DAY 9	30	60	7	0.033	3	492	0.304	12	
DAY 10	27	69	5	0.046	6	589	0.63	25		DAY 10	28	66	7	0.046	8	505	0.57	23	
Total	248	631	53	0.682	62	556.4	6.606	262			296	620	128	0.431	58	5,536	5.564	207	
-:-	10	10	10	10	10	10	10	10		-:-	10	10	10	10	10	10	10	10	
Aver-age	24.8	63.1	5.3	0.0682	6.2	556.4	0.6606	26.2			29.6	62	12.8	0.431	5.8	553.6	0.5564	20.7	

Table 8: Air Quality Measurements at College of Medicine.

DAY 7 Tues-day	**Morning Parameters**									**Afternoon Parameters**								
Loca-tions	TEMP. 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	RE MA RKS	TEMP. 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	RE MA RKS
DAY 1	-	-	-	-	-	-	-	-		29	58	10	0.032	6	546	0.437	20	
DAY 2	28	66	103	0.038	9	614	0.784	46		30	56	10	0.021	4	505	0.356	15	
DAY 3	26	74	16	0.06	8	687	0.971	31		29	65	7	0.025	6	524	0.413	16	
DAY 4	28	64	7	0.028	3	519	0.396	16		29	59	13	0.038	4	451	0.174	7	
DAY 5	28	71	9	0.042	5	518	0.405	17		29	65	5	0.032	5	502	0.355	14	
DAY 6	29	67	8	0.051	3	512	0.371	15		33	53	7	0.041	4	545	0.472	21	
DAY 7	29	69	5	0.048	7	608	0.705	27		29	63	6	0.032	7	505	0.562	23	
DAY 8	26	73	6	0.037	5	548	0.532	22		30	63	5	0.03	5	502	0.354	14	
DAY 9	27	69	5	0.037	5	519	0.395	16		27	64	5	0.045	7	608	0.689	26	
DAY 10	27	69	3	0.047	7	517	0.583	24		29	62	16	0.055	7	605	0.621	19	
Total	248	622	162	0.388	52	5,042	5.062	214		294	608	84	0.351	55	5,293	4.493	175	
-:-	10	10	10	10	10	10	10	10	-:-	10	10	10	10	10	10	10	10	
Aver-age	24.8	62.2	16.2	0.0388	5.2	504.2	0.5062	21.4		29.4	60.8	8.4	0.0351	5.5	529.3	0.4493	17.5	

Table 9: Air Quality Measurements at Senate Building.

DAY 8 Wednesday	Morning Parameters									Afternoon Parameters								
Locations	TEMP. 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	REMARKS	TEMP. 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	REMARKS
DAY 1	-	-	-	-	-	-	-	-		30	60	9	0.038	6	593	0.656	26	
DAY 2	27	70	7	0.051	8	610	0.899	30		31	51	10	0.055	7	649	0.863	29	
DAY 3	27	74	8	0.047	7	625	0.748	27		29	70	6	0.052	5	547	0.498	19	
DAY 4	30	58	4	0.033	4	510	0.387	16		30	62	7	0.052	5	511	0.366	15	
DAY 5	29	65	6	0.061	4	552	0.515	21		29	67	10	0.032	6	487	0.305	13	
DAY 6	28	70	10	0.053	3	518	0.386	16		34	54	6	0.065	6	577	0.598	21	
DAY 7	30	66	6	0.046	6	592	0.639	25		32	57	5	0.041	4	542	0.478	20	
DAY 8	28	66	9	0.043	4	527	0.421	17		29	67	11	0.031	4	483	0.283	12	
DAY 9	29	65	5	0.043	5	513	0.385	19		28	62	3	0.046	7	570	0.577	24	
DAY 10	28	66	18	0.056	5	502	0.063	15		29	62	17	0.062	6	521	0.408	17	
Total	256	600	73	0.0433	46	4.949	4.743	186		301	612	84	0.474	56	5480	5.032	187	
-:-	10	10	10	10	10	10	10	10	-:-	10	10	10	10	10	10	10	10	
Average	25.6	60	7.3	0.0433	4.6	0.4949	0.4743	25.6		30	60	9	0.038	6	593	0.656	26	

Table 10: Air Quality Measurements at Block C.

Day 9 Thursday	Morning Parameters									Afternoon Parameters								
Locations	TEMP. 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	REMARKS	TEMP. 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	REMARKS
DAY 1	-	-	-	-	-	-	-	-		30	58	9	23	5	585	0.627	25	
DAY 2	27	71	7	0.0045	9	692	0.994	31		29	59	6	0.033	8	620	0.777	28	
DAY 3	26	76	6	0.05	9	660	0.857	30		29	65	3	0.031	5	497	0.326	13	
DAY 4	28	67	10	0.0073	10	697	0.973	31		28	64	18	0.027	3	502	0.341	14	
DAY 5	27	72	7	0.0027	8	640	0.816	29		31	60	15	0.03	3	480	0.271	11	
DAY 6	27	75	8	0.052	7	607	0.816	26		33	53	9	0.023	5	506	0.372	14	
DAY 7	27	72	9	0.035	8	691	0.959	32		30	61	7	0.033	4	535	0.448	19	
DAY 8	27	66	5	0.045	8	706	1.039	32		31	60	9	0.042	5	507	0.349	14	
DAY 9	26	72	8	0.033	8	624	0.751	28		31	62	7	0.038	4	578	0.403	16	
DAY 10	27	73	4	0.05	8	690	0.981	31		30	59	15	0.032	4	486	0.28	12	
	242	644	64	0.408	75	6007	8.007	270		302	601	98	0.323	4.6	5260	4194	396	
-:-	10	10	10	10	10	10	10	10	-:-	10	10	10	10	10	10	10	10	
	24.2	64.4	64	0.408	7.5	600.7	0.8007	27		30.2	60.1	9.8	0.0323	4.6	526	419.4	39.6	

Table 11: Air Quality Measurements at Faculty of Natural and Applied Science.

DAY 10 Fri-day	Morning Parameters									Afternoon Parameters								
Loca-tions	TEMP. 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	RE MA RKS	TEMP. 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	RE MA RKS
DAY 1	-	-	-	-	-	-	-	-		30	59	10	0.058	8	644	0.835	28	
DAY 2	27	70	13	0.048	9	644	0.899	30		30	60	10	0.026	7	580	0.576	23	
DAY 3	25	77	6	0.048	7	655	0.833	29		29	65	7	0.031	5	488	0.288	11	
DAY 4	28	69	6	0.058	6	625	0.763	27		28	63	11	0.037	4	506	0.354	14	
DAY 5	27	71	5	0.037	7	647	0.832	29		30	63	13	0.078	4	555	0.518	23	
DAY 6	27	73	8	0.048	7	606	0.682	26		32	52	9	0.075	3	496	0.323	13	
DAY 7	28	69	9	0.031	8	636	0.785	28		30	61	6	0.032	5	533	0.446	18	
DAY 8	27	67	6	0.038	5	546	0.53	20		30	63	10	0.047	5	540	0.495	20	
DAY 9	26	72	8	0.027	8	618	0.733	27		30	62	9	0.022	6	524	0.412	17	
DAY 10	27	72	9	61	7	658	0.887	30		29	62	11	0.076	4	554	0.516	23	
Total	242	640	70	0.396	64	5.655	6.944	246		2717	610	96	0.422	51	5420	4.763	190	
-:-	10	10	10	10	10	10	10	10	-:-	10	10	10	10	10	10	10	10	
Aver-age	24.2	64	7	0.0396	6.4	565.5	0.6944	24.6		271.7	61	9.6	0.0422	51	542	0.4763	19	

Table 12: Average Values of Air Quality Measurements.

Day 5	**Morning Parameters**									**Afternoon Parameters**								
Lo-ca-tions	TEMP. 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	RE MA RKS	TEMP. 0C	RH	Pm 2.5	HCHO	CO	CO2	TVCO	AQI	RE MA RKS
1	25.6	58.7	5.7	0.0338	4	468.3	0.3568	17.4		27.4	64.6	6.2	0.0495	6.1	586.1	0.6249	21.2	
2	24.3	63.6	6.2	0.127	6.5	583.7	0.7897	25.7		30.2	60.1	7.2	0.0421	6.6	606.3	0.4758	20.1	
3	24.8	63.1	6.2	0.2515	8.2	632.5	1.9256	39.8		30.1	60.9	8.2	0.1623	6.8	621.6	0.8369	42.4	
4	26	58.2	7.8	0.0313	4.1	455	0.3256	13.1		29.1	82.9	8.4	0.6453	4.6	509.3	0.3665	20.7	
5	25.7	57.6	7.3	0.0328	4.3	458.6	0.3309	15.2		28.4	61.8	7.2	0.0498	5.7	569.8	0.5722	20.4	
6	24.8	63.1	5.3	0.0682	6.2	556.4	0.6606	26.2		29.6	62	12.8	0.431	5.8	553.6	0.3364	20.7	
7	24.8	62.1	16.2	0.0388	5.2	504.2	0.5052	21.4		29.4	60.8	8.4	0.0351	5.5	529.3	0.4403	17.5	
8	25.6	60	7.3	0.0433	4.6	0.4949	0.4743	25.6		30	60	9	0.038	6	593	0.656	26	
9	24.2	64.4	6.4	0.408	7.5	600.7	0.8007	27		30.2	60.1	9.5	0.0323	7.6	526	419.4	39.6	
10	24.2	64	7	0.0396	6.4	565.5	0.6544	24.6		27.7	41	9.6	0.0422	5.1	542	0.4763	19	

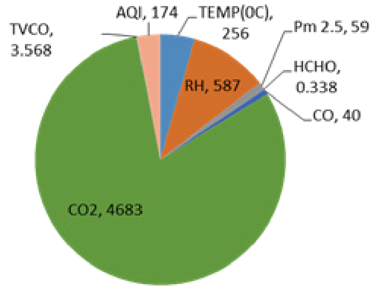

Figure 1: DAY 1- NUR/EHS/CHEW-MORNING.

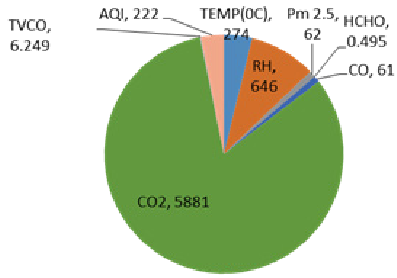

Figure 2: DAY 1- NUR/EHS/CHEW-AFTERNOON.

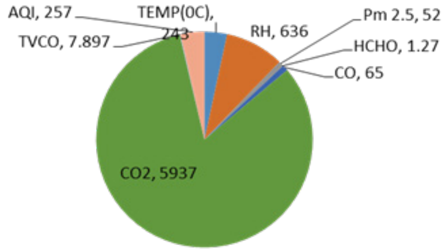

Figure 3: DAY 2- LIBRARY-MORNING.

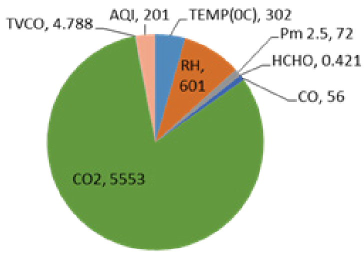

Figure 4: DAY 2- LIBRARY-AFTERNOON.

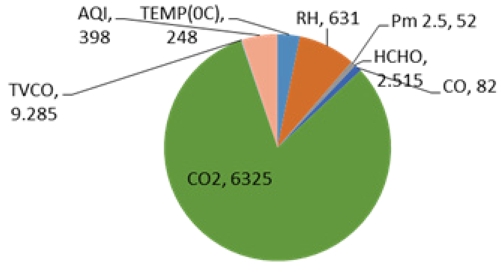

Figure 5: DAY 3- CLINIC-MORNING.

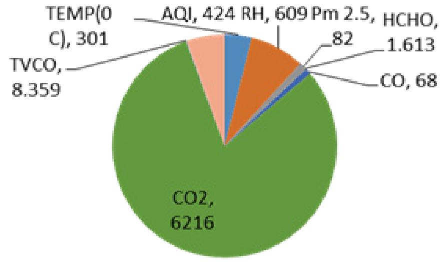

Figure 6: DAY 3- CLINIC-AFTERNOON.'

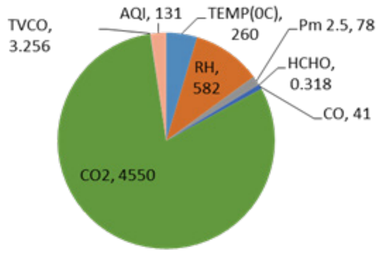

Figure 7: DAY 4- LAW THEATRE- MORNING.

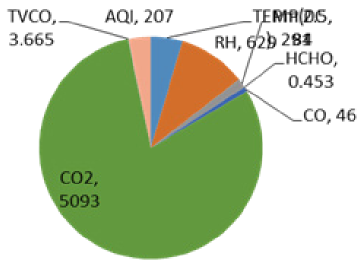

Figure 8: DAY 4- LAW THEATRE- AFTERNOON.

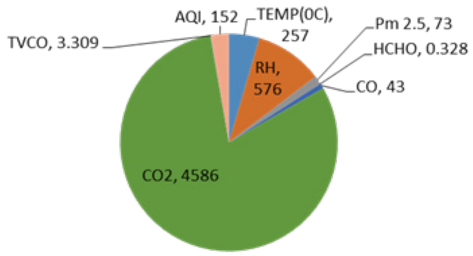

Figure 9: DAY 5- FACULTY OF PHARMACY.

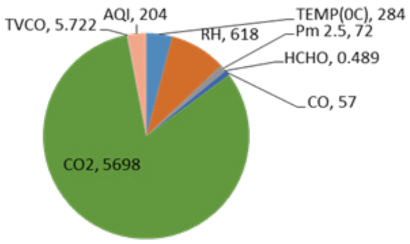

Figure 10: DAY 5- FACULTY OF PHARMACY-AFTERNOON.

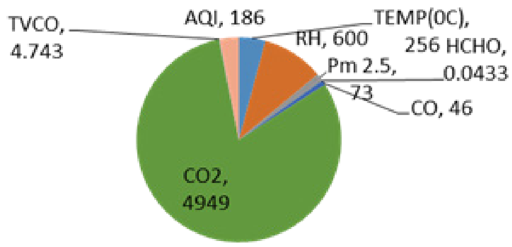

Figure 11: DAY 6-SENATE-MORNING.

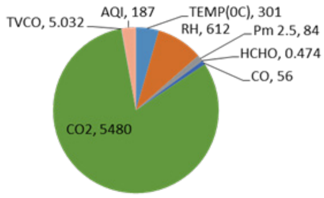

Figure 12: DAY 6-SENATE-AFTERNOON.

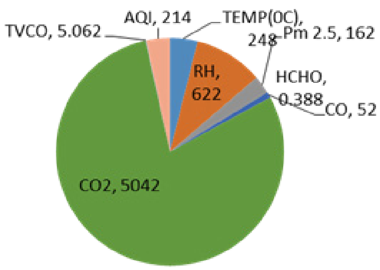

Figure 13: DAY 7-COLLEGE OF MEDICINE-MORNING.

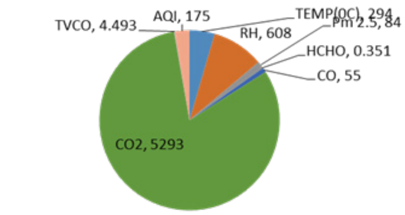

Figure 14: DAY 7-COLLEGE OF MEDICINE-AFTERNOON.

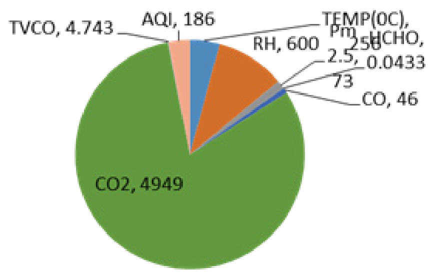

Figure 15: DAY 8-SENATE-MORNING.

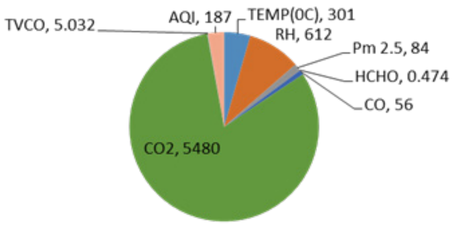

Figure 16: DAY 8-SENATE-AFTERNOON.

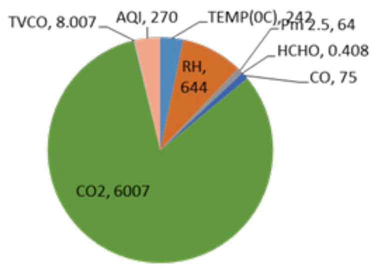

Figure 17: DAY 9-BLOCK C-MORNING.

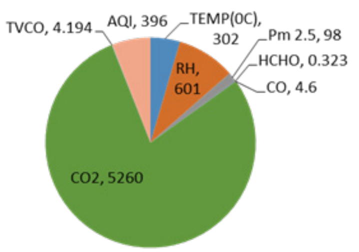

Figure 18: DAY 9-BLOCK C-AFTERNOON.

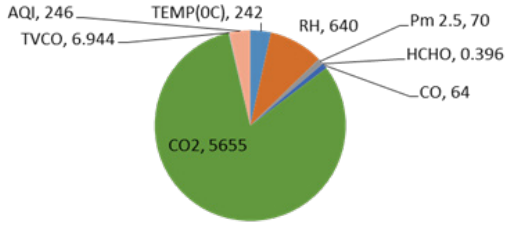

Figure 19: DAY 10-FACULTY OF NATURAL AND APPLIED SCIENCE-MORNING.

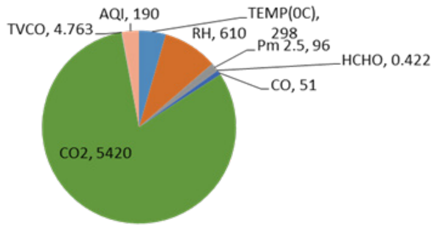

Figure 20: DAY 10-FACULTY OF NATURAL AND APPLIED SCIENCE-AFTERNOON.

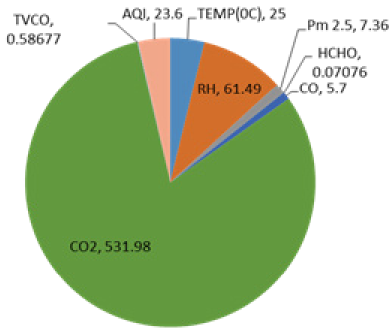

Figure 21: AVERAGE MORNING MEASUREMENTS FOR ALL LOCATIONS.

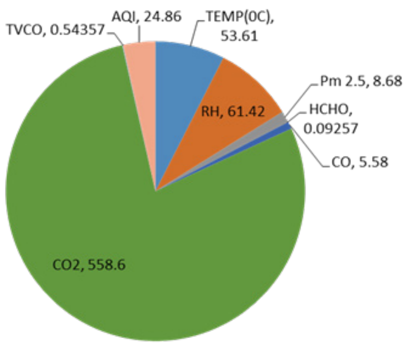

Figure 22: AVERAGE AFTERNOON MEASUREMENTS FOR ALL LOCATIONS.

Discussion of Findings

The study investigated various environmental parameters across different classroom locations, including morning temperature, Relative Humidity (RH), CO_2 levels, CO levels, and Particulate Matter (PM) levels at Lead City University. Morning temperature exhibited significant variability across classroom locations, with the faculty of pharmacy experiencing the highest variance, suggesting extreme temperature fluctuations (25.7°C). Block C and Faculty of Natural and Applied Science had lower temperature variances (24.2°C), indicating more stable conditions. RH showed wide variations, with the Block C having the highest variance (64.4%), implying substantial humidity fluctuations. Faculty of Natural and Applied Science also exhibited high RH variances (64%), potentially impacting indoor air quality and comfort. Morning CO_2 levels varied considerably, with University clinic and Block C pitch showing notably high variances (632.5%) and (600.7%) respectively, indicating potential pollution sources. Senate building and Law theatre had lower CO_2 variances, suggesting better air quality management. Morning CO levels displayed a significant range, with the University clinic exhibiting remarkably high variance (8.2ppm), indicating substantial fluctuations in air pollution. Law theatre and faculty of pharmacy had relatively stable CO levels. Morning PM levels varied widely, with College of Medicine having an exceptionally high variance (16.2µg/m^3), signifying severe particulate matter variability. In contrast, university clinic and university library maintained lower PM variances (6.2µg/m^3), reflecting more consistent air quality.

Consequently, afternoon temperature variance was highest at Workshop, potentially affecting indoor comfort and energy consumption. Senate and Chapel exhibited lower temperature variances, providing more stable conditions.

Conclusion

The study revealed significant variations in environmental parameters across different classroom locations, highlighting the diverse conditions within the study area. These findings are consistent with the concept of microclimates influenced by local factors, including urbanization, geographical features, and climate patterns. Variability in these parameters can have implications for human health, indoor air quality, and energy consumption.

Recommendations

Based on the concluded findings, the following recommendations could be made;

i. Urban Planning and Management: Urban areas should consider the impact of urbanization and implement effective urban planning and management strategies to mitigate temperature and pollution fluctuations, especially in high-variance locations.

ii. Indoor Air Quality Management: Locations with high CO_2 variance should focus on improving indoor air quality through adequate ventilation and pollution control measures. Healthcare facilities, in particular, should prioritize indoor air quality to ensure patient well-being.

iii. Traffic Management: Areas with high CO variance should explore traffic management solutions to reduce air pollution fluctuations, such as congestion and industrial emissions.

iv. Waste Management: Effective waste management and pollution control measures are essential, as demonstrated by the exceptionally high PM variance at the Dumpsite. Rigorous waste management practices can help contain pollution.

v. Climate-Responsive Design: Locations with high temperature and RH variances should consider climate-responsive building design and energy-efficient solutions to enhance occupant comfort and reduce energy consumption.

vi. Healthcare Facility Planning: Healthcare settings, where stable environmental conditions are crucial, should prioritize RH and CO_2 control to maintain patient comfort and prevent mold growth.

vii. Research and Monitoring: Continual research and monitoring of environmental parameters are essential to assess long-term trends, identify pollution sources, and implement effective mitigation strategies.

Hence, these recommendations aim to address the observed environmental variations and enhance the quality of life, health, and sustainability within the study area.

Acknowledgement

None.

Conflict of Interest

None.

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