Comparative Assessment of Air Quality Status at Abura Market, Kotokuraba Market and University of Cape Coast Science Market

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ABSTRACT

Air pollution is one of the major environmental problems, which in urban areas reaches an exceptional degree due to high population density and economic activities. Therefore, this study provides a comparative assessment of air quality at three main markets: Abura Market, Kotokuraba Market, and UCC Science Market. in Cape Coast metropolis using air quality detector D9. The main aim is to measure and contrast levels of main air pollutants, such as PM2.5, PM10, CO2, HCHO, and TVOC, between these markets other specific objectives are;To measure the concentration level of CO_2, VOC_S, $PM_{2.5,}$ $CO_{2,}$ PM_{10} HCHO using air quality detector D9 between 6am and 8am in the morning and 4pm and 6pm in the evenimg. To compare the air quality data obtained from the three markets to determine which area has the highest and lowest levels of pollution in Cape Coast metropolis. Air quality detector D9 collects data on PM2.5, PM10, CO2 and HCHO were recorded at 2 minutes intervals over a span of 2 hours in both the morning and evening for a period of two weeks in each market. This data collection was conducted at various points within each market. SPSS and excel was used to analyze the data. The results indicate a wide variability in air quality between the three markets. The highest level of PM2.5 (51.8 µg/m³) and PM10 (69.2 µg/m³), which is above the WHO guidelines, occurred at Abura Market, especially in the evening. UCC Science Market showed a high reading of PM in the morning where PM2.5 was 38.8 µg/m3 and PM10 of 45.3 µg/m3 slightly above the WHO guidelines. CO2 levels in all the markets were above the safety limits, indicating possible ventilation problems.TVOC and HCHO apper to be negligible or close to zero in all the three markets in bboth morning and eveving. These results call for the implementation of focused interventions to ameliorate air quality in these markets. Other recommended measures to be taken include constant air quality monitoring, education of the public on pollution prevention, and increased control over vehicle and industrial emissions within the vicinity of markets. Implementation of such is very necessary to minimize health risks related to poor air quality in Cape Coast's markets.

INTRODUCTION

Air pollution is the presence in the atmosphere of substances that are harmful or excessive, with possible various undesirable effects on human health, the environment, and quality of life (WHO, 2021). Sources of such pollutants may be from industrial activities, transportation, agriculture, natural processes, among others. One of the major sources of air pollution, especially in urban cities, includes the transport sector. It has been reported that in developing countries, most of the air pollution (70-80%) comes from the vehicular emission particularly from larger numbers of older vehicles with low vehicle maintenance, low fuel quality, and improper road infrastructure (Wang et al., 2010; Bigazzi and Figliozzi, 2014). burning of fossil fuels, such as coal, oil, and gas, releases large amount of pollutants into the atmosphere: sulfur dioxide, nitrogen oxides, carbon monoxide, and particulates this can cause both cardiovascular and respiratory diseases. he major air pollutants that are responsible for degrading air quality are oxides of nitrogen (NO_X), sulfur dioxide (SO_2), carbon monoxide (CO), particulate matter (PM), volatile organic compounds (VOC) and ozone (O_3)

Globally, air pollution has become a pressing concern, with urban areas experiencing high levels of pollution due to vehicular emissions, industrial activities, and other sources. According to WHO, air pollution is responsible for millions of premature deaths each year and is linked to a range of health problems, including

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respiratory diseases, cardiovascular issues, and even cancer. (WHO, 2018). Many African cities are experiencing rapid growth, which is often accompanied by increased industrial activities and vehicle emissions. For instance, cities like Lagos, Cairo, and Johannesburg have seen significant rises in air pollution levels, primarily due to the burning of fossil fuels in transportation and industrial processes (UNEP, 2019). In Ghana, air pollution is also a growing problem that poses risks to public health and the environment. Rapid urbanization, industrial growth, and increasing vehicular traffic have contributed to worsening air quality in major cities like Accra and Kumasi. At the moment no work has been on air quality on highly populated market that can pose risk to the people .Therefore there is the need to assess the air quality status at Abura market, Kotokuraba market and UCC science market. The objectives of the study are to assess and compare the levels of various air pollutants in Abura Market, Kotokroba Market, and UCC Science Market in Cape Coast metropolis using air quality detector D9, To measure the concentration level of CO_2, VOC_S, $PM_{2.5,}$ $CO_{2,}$ PM_{10} HCHO using air quality detector D9 between 6am and 8am in the morning and 4pm and 6pm in the evening,

MATERIALS AND METHOD

Study Area

Cape Coast, the historic capital of Ghana, is located in the southern part of the country, extending into the Gulf of Guinea, an arm of the Atlantic Ocean. The city covers an area of 122 km² and, according to the Ghana Statistical Service (2021) population and housing census, has a population of 189,925. Geographically, the Cape Coast Metropolis lies between longitudes 1.11º and 1.41º west of the Greenwich Meridian and latitudes 5.07º and 5.20º north of the Equator. The region experiences relative humidity levels ranging from 70% to 90%, with temperatures varying between 24 and 32 degrees Celsius. High temperatures persist throughout the year, with the coolest months being June, July, and August, and the hottest months occurring in February and March. Climate variations in Cape Coast are primarily influenced by rainfall patterns.

Kotokuraba Market

Kotokuraba, located in Ghana's Central Region along the coast, is part of Cape Coast, a city renowned for its historical and cultural heritage. Positioned near the Gulf of Guinea, which is part of the Atlantic Ocean, Kotokuraba's coastal location significantly influences its climate, economy, and lifestyle. It lies at the latitude of 5°7'6.69" and longitude of 1°15'6.18", approximately 165 kilometers west of Accra, the capital city. The local economy thrives on diverse activities characteristic of a coastal community. The busy market is a center for traders and artisans, offering a wide range of goods from fresh produce to handcrafted items, attracting numerous visitors. Tourism is also a growing sector, with Kotokuraba's proximity to historic sites and beautiful beaches drawing tourists interested in cultural experiences and relaxation. However, Kotokuraba is vulnerable to air pollution due to its economic activities and high population density.

University of Cape Coast

The Central Region of Ghana, covering an area of 9,826 square kilometers, is the third smallest region in the country. According to the 2000 Population and Housing Census Report, the Central Region shares boundaries with the Western Region to the west, and with the Ashanti and Eastern regions to the north (Drislane et al ., 2014)

The region was the first area in the country to make contact with the Europeans. Its capital, Cape Coast was the capital of the Gold Coast until 1877 when the capital was moved to Accra. The region has two Universities, university of Cape Coast and university of education Winneba. There are other excellent Senior High Schools like, Mfantsipim Senior High School, Adisadel College, and Holy child. etc.

The main economic activities are salt mining and fishing along the coast. There are lagoons in addition to the sea which makes fish farming a prominent feature along the coast.

The University of Cape Coast market serves as a pivotal trading center for both visitors, students, stuff and

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neighboring communities, it is located between coordinates 5.1155° N, 1.2909°. The market is situated at the new site of the university campus, which is about 60 meters from the central administration. This market is 90 meters to college of agriculture and natural science building.

Abura Market

Abura is located at the Cape Coast North onstituency with the coordinate of 5.1342° N, 1.2887° W. Abura market is a relatively small market that serves suburbs like Adisadel, Akotokyir, Kakumdo, Pedu, the Cape Coast Technical University and the University of Cape Coast(Yaffeto et al 2019).This market is near to the roadside of which people sell and buy at the roadside.

Site Selection

In the Cape Coast Metropolis, which hosts over 50 markets, the selection of Abura Market, Kotokroba Market, and UCC Science Market for the study was strategically based on several criteria: the density of people who buy or sell in these markets, the intensity of economic activities, and the overall population size. These markets are known for their high density and significant population, making them particularly susceptible to air pollution due to the bustling activities that take place there, operating from 6 a.m. to 6 p.m., people spend approximately 12 hours daily in these markets. This extended exposure to the market environment increases the risk of air pollution, posing potential health hazards to those who spend half of their day in these settings.

Market used in this study.

Ghana markets palces operates very informal ,most of the vendors set up stalls in an unplanned areas like beside roadside. Market like Abura , UCC science market and and Kotokuraba market are mostly highly populated with vendors selling beside roadside and unauthorized areas.This can lead to environmental issues such as poor air circulation and many more. Air quality in Ghanaian markets is compromised due to many factors such burning waste in the markets and the use of charcoal by food vendors in the market , this can release significat amount of pollutants which can have consequncies on the people.

Sampling

Each market was divided into three different zones based on the density of human activity and proximity to sources of pollution (e.g., main roads, cooking areas, waste disposal sites). Air quality detector was placed at three places within market environment. Zone 1 was higly populated environment within the market , Zone 2 medium populated as compared to zone 1 in the market and finally Zone 3 was low populated area within the market. Measuring of air quality was done in two weeks in each markets twice a day in the morning from 7am to 9am and in the evening between 4pm and 6pm.

Equipment Description

For this research air quality detector D9 was used to ensure accurate and reliable data collection. These devices have been thoroughly tested, inspected, and packed before use, ensuring their performance meets our research needs.

The D9 monitors measure a range of air quality parameters with the following detection ranges:$PM_{2.5}$: 0 to 6000 µg/m³,TVOC: 0.000 to 2.000 mg/m³, HCHO: 0.000 to 2.500 mg/m³, CO_2: 400 to 4000 ppm.

METHODOLOGY

Abura market, Kotokuraba market and UCC market which have high visitors density was collected. between June 1, 2024, and July 14, 2024. These markets, all of which are outdoor environment, were monitored every morning and evening over a two-week period for each market. During these times, air quality detector D9 collect data on PM2.5, PM10, CO2 and HCHO, were recorded at 2 minutes intervals over a span of 2 hours in both the morning and evening. This data collection was conducted at various points within each market.The data was analyze using SPSS and excel.

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RESULTS

Table 1: Analysis of variance between location and pollutants.

Values obtain					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	346686.753	2	173343.377	4.823	.008
Within Groups	301921806.618	8401	35938.794		
Total	**302268493.372**	**8403**			

This table summarizes the analysis of variance between different locations concerning pollutant

The ANOVA analysis shows that there is a statistically significant difference between different location and pollutants. The F-value of 4.823 and the p-value of .008 together suggest that the differences in means among the groups are unlikely to be due to random variation. Specifically, this p-value indicates strong evidence against the null hypothesis of equal group means, meaning that at least one group mean is significantly different from the others.

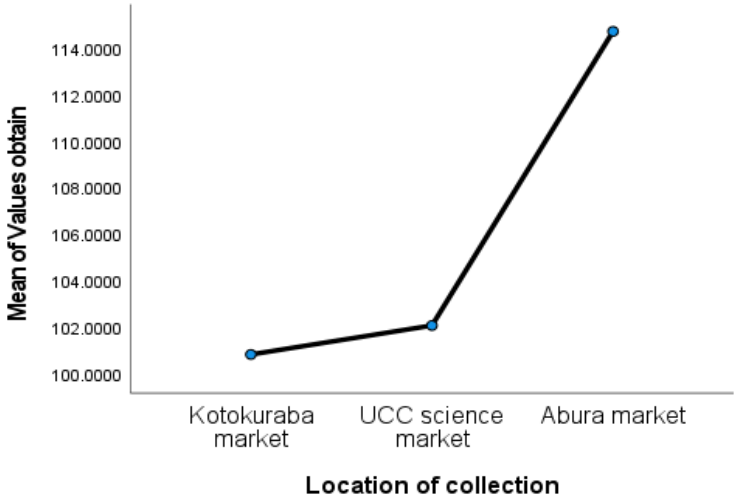

Figure 1: Mean Plots Of Pollutant At Difference Location.

The graph suggests that air pollution is relatively consistent between Kotokuraba Market and UCC Science Market. However, there is a substantial increase in the mean values at Abura Market, which could indicate higher levels of the measured parameter at this location.

This significant difference at Abura Market may warrant further investigation to understand the factors contributing to the elevated mean values. It could be due to higher pollution levels, increased human activity, different environmental conditions, or other site-specific factors.

Table 2: Analysis of variance between time and pollutants.

Values obtain					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	504172.775	1	504172.775	14.038	<.001

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Within Groups	301764320.597	8402	35915.773		
Total	**302268493.372**	**8403**			

This table analyzes the relationship between time and pollutant levels. This analysis is crucial for understanding how pollutant concentrations may vary over different time periods.

The ANOVA analysis reveals a statistically significant difference between time and pollutamts means being compared. The F-value of 14.038 and the very low p-value (< .001) together suggest that the difference in means is not due to random variation. This indicates that the independent variable has a significant effect on the dependent variable, leading to a meaningful difference between the two groups

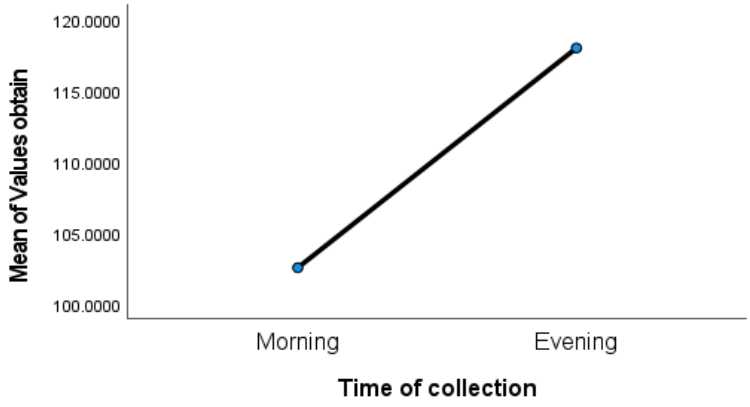

Figure 2: Mean plots of pollutant at different time.

Table 3: Averages of pollutants at various location in the morning

Pollutants	**Abura Market**	**Science Market**	**Kotokuraba Market**
$PM_{2.}$ (ug/m^3)	12.8	38.8	32.8
$PM_{10.}$ (ug/m^3)	17.1	45.3	38.2
$CO_{2.}$ (ppm)	470.3	470.3	441.6
HCHO(ug/m^3)	0.01	0.01	0.01
TVOC	0.29	0.25	0.21

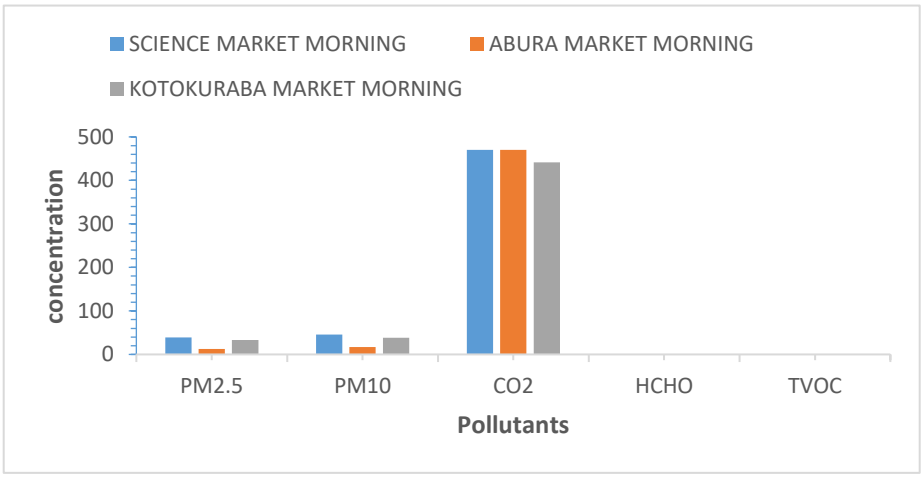

Figure 3: A chart showing pollutants and their concentration in the morning at various markets

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Table 4:Averages of pollutants at various location in the evening.

Pollutant	Abura Market	Science Market	Kotokuraba Market
$PM_{2.5}$	51.8	32.9	30.1
PM_{10}	69.2	38.2	32.1
CO_2	524.6	441.6	436.3
HCHO	0.02	0.01	0.02
TVOC	0.34	0.27	0.22

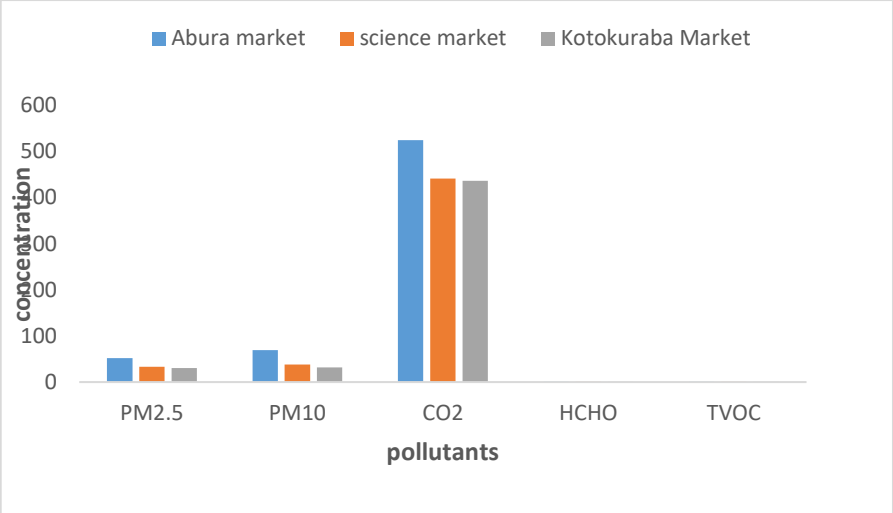

Figure 4 :A chart showing pollutants and their concentration in the evening at various markets

DISCUSSION

A comparative assessment of air quality at Abura Market, Kotokuraba Market, and UCC Science Market in Cape Coast, Ghana, shows great variations in pollutant concentrations during morning and evening periods. In the morning, particulate matter, both PM2.5 and PM10, is considerably high at the Science Market, with recorded levels of PM2.5 at 38.8 µg/m³ and PM10 at 45.3 µg/m³. These are way above the WHO guidelines, which suggests PM2.5 not above 25 µg/m³ and PM10 not above 50 µg/m³, both for 24-hour exposure. Abura Market showed a relatively lower level of PM2.5 at 12.8 µg/m³ and PM10 of 17.1 µg/m³. In addition, Kotokuraba Market recorded PM2.5 of 32.8 µg/m³ and PM10 of 38.2 µg/m³, with both of them also getting over the limits set by the guidelines. During the evening, there was a different trend in pollutant levels; particulate matter was still high in concentrations, while the overall trend was that of increasing concentrations, contributing to factors such as increased vehicular traffic and localized activities relating to market operations. All evening measurements showed that Abura market had the highest recordings of PM2.5 and PM10. Abura Market recorded PM2.5 of 51.8 µg/m³ and a PM10 of 69.2 µg/m³, which is far above the WHO guidelines. Science Market showed a PM2.5 at 32.9 µg/m³ and PM10 at 38.2 µg/m³. Kotokuraba Market showed PM2.5 at 30.1 µg/m³ and PM10 at 32.1 µg/m³. These evening concentrations of particulate matter are above the World Health Organization guideline values for both PM2.5 (25 µg/m³ for 24-hour mean) and PM10 (50 µg/m³ for 24-hour mean), which implies a serious health concern for vendors and customers in these markets. Disturbingly, CO2 levels were also high across the board. This was measured at approximately 470 µg/m³ in both the Science and Abura Markets in the morning, which is well above the threshold of 400 µg/m³ often used to define poor air quality in enclosed spaces. In the evening, the CO2 reading had accordingly risen to: Abura Market at 524.6 µg/m³, Science Market at 441.6 µg/m³, and Kotokuraba Market at 436.3 µg/m³. These high CO2 concentrations indicate poor ventilation and are more likely in crowded market environments where there is restricted air exchange. Formaldehyde (HCHO) concentrations were also relatively stable at 0.01 µg/m³ in the Science Market and 0.02 µg/m³ in both Abura and

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Kotokuraba Markets. These concentrations, though consistent, are very low when compared to the recommended WHO guideline value of 100 µg/m³, thus posing no real threat at present from this pollutant. The levels of TVOC were 0.25 µg/m³ in the Science Market, 0.29 µg/m³ in Abura Market, and 0.21 µg/m³ in Kotokuraba Market, all below the threshold of 0.5 mg/m³, which raises concern about health risks. Thus, though particulate matter is threatening health risks, the concentrations of both VOCs and formaldehyde have levels within the acceptable limits. The ANOVA of the present study indicated that the pollutant levels differed significantly among the three locations in the market; for location, $p = 0.008$, and for time, $p < 0.001$. This establishes that both location and time of day significantly influence air quality. The combined results from both morning and evening assessments underline critical air quality issues within the markets in Cape Coast. The constantly increased levels of particulate matter, mainly within the Science and Abura markets, are several times higher than the WHO guidelines and pose a serious health threat to both vendors and customers. Also, the heightened levels of CO2 makes ventilation the worst, probably enhancing health issues in these places.

CONCLUSION

Urban marketplaces throughout the country have often been pinpointed as major sources of air pollution in the nation's atmosphere. This research work measures the air quality at three urban markets located in Cape Coast, Ghana. The study addresses the very crucial issue of air pollution, which poses severe threats to public health and environmental sustainability.

The study demonstrated the urgent need for understanding and improving air quality in urban markets where human activity is highly concentrated. The data from three different markets showed different trends of pollutant concentrations that indicate Abura Market, Kotokuraba Market, and UCC Science Market have different air quality profiles. The results show that different markets are more negatively affected by pollution, and as such, interventions need to be designed with those effects in mind. The very low p-values from the ANOVA tests confirm that the variations in pollutant levels did not occur by chance, and hence, location and temporal factors are important when it comes to the assessment of air quality.

RECOMMENDATION

A comprehensive air quality management plan will, therefore, be of instrumental importance in serving the three identified air quality issues at Abura Market, Kotokuraba Market, and UCC Science Market. The plan shall involve continuous monitoring of pollutant levels, public education programs, and more stringent regulatory measures with regard to emissions. Real-time air quality monitoring will avail credible data on pollution trends over time and will inform stakeholders on the related health risks. In addition, public awareness campaigns should be carried out regarding market vendors and customers to educate them on the sources and effects of air pollution, ways of minimizing waste burning, and promoting cleaner modes of transportation. Moreover, the cooperation with local authorities in imposing stricter limits on vehicle and industrial emissions will help reduce pollution levels. Through the implementation of these measures, stakeholders can aim to improve air quality, protect public health, and ensure a healthier environment in Cape Coast markets environments.