ACAVIS PUBLISHERS

Annals of Environmental Engineering

Research Article

Volume 1, Issue 1

Assessment of Air Quality at Kejetia Market in Kumasi, Ashanti Region

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ABSTRACT

This study assessed air quality in Kejetia Market, Kumasi, Ghana, with a focus on particulate matter ($PM_{2.5}$ and PM_{10}), sulphur dioxide (SO_2), and carbon monoxide (CO_2). A cross-sectional descriptive design was employed, with continuous 24-hour measurements taken over 36 days at two bus terminals and one non-bus terminal using Haz-Dust Environmental Air Monitor and Aeroqual Series 500 device. Data were analyzed with descriptive statistics, correlation tests, and health risk evaluations based on World Health Organization (WHO) and U.S. EPA Air Quality Index (AQI) standards. Results revealed that $PM_{2.5}$ and PM_2 concentrations across all sites substantially exceeded WHO 24-hour guideline values, with average levels ranging between 540–640 μg/m³ for $PM_{2.5}$ and 620–780 μg/m³ for PM_{10}, placing air quality in the "hazardous" AQI category. CO concentrations also exceeded the WHO 24-hour threshold at the bus terminals (6.58–7.23 mg/m³), though values were lower at the non-bus terminal (0.52 mg/m³). SO_2 levels were minimal, with negligible concentrations at the non-bus terminal. Correlation analysis indicated strong positive relationships for $PM_{2.5}$ and CO between the bus terminals, while PM_{10} and SO_2 showed more site-specific variability. The findings underscore that Kejetia Market, particularly its bus terminals, is a hotspot for hazardous air pollution primarily from vehicular emissions and resuspended dust.

Graphical Abstract

KEYWORDS: Air quality, Health risk, Market, Ghana, Particulate matter, Gases.

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Article Info:
Received Date: June 02, 2026
Published Date: June 19, 2026

Citation:
Lyndon NA Sackey, Joshua S Owarie, Daniel KO Asamoah. Assessment of Air Quality at Kejetia Market in Kumasi, Ashanti Region. Ann Env Eng. 2026;1(1):1-9.

HIGHLIGHTS

- $PM_{2.5}$ and PM_{10} concentrations at the sites exceeded WHO 24-hour guideline values.
- SO_2 levels were minimal, with negligible concentrations at the non-bus terminal.
- CO concentrations exceeded the WHO 24-hour threshold at the bus terminals
- The poor air quality poses significant health risks to traders, transport operators, and commuters.

INTRODUCTION

Air pollution is one of the major emerging environmental threats globally, largely due to the increased consumption of fossil fuels in industrialisation, transportation, and urbanisation, which is fueled by exponential population growth.[1] The UNEP Pollution Action Note reports that air pollution globally accounts for more than 8 million premature deaths every year.[2] Although clean air is fundamental to health, it is estimated that in 2021, 99% of the global population lived in places where air quality exceeded the annual WHO air quality guidelines.[2] In low and middle-income countries today, such as Ghana, individuals are exposed to about one to four times higher levels of air pollution than those in high-income countries. In Ghana, reliance on wood and other solid fuels, the use of kerosene for lighting, vehicular emissions, construction dust and waste burning are the main sources of air pollution. However, in some parts of Africa and West Asia, windblown dust is also a major source of air pollution in areas close to deserts. These anthropogenic and natural phenomena exacerbate the emission of pollutants, including Particulate Matter (PM), Nitrogen Oxides (NO_x), Sulfur dioxide (SO_2), Carbon monoxide (CO), and Volatile Organic Compounds (VOCs).[3] Air pollutants are capable of crossing borders to impact the air quality and environment of neighboring countries, not just their origin. They present a serious environmental and public health risk and are massive contributors to climate change, threatening food security.

Air pollution has become a critical issue in developing countries' urban markets, driven by rapid city growth and industrial development. Africa's urban markets, such as Lagos, show dangerous levels of air pollution, recording air pollutants like PM, SO_2, and CO levels well above the WHO standards.[4] Ghana's story mirrors many developing nations. Its urban centres, particularly Accra, struggle with severe air pollution from vehicles and industry.[5,6]

In Ghana, markets serve as vital economic centres, but they face significant air quality challenges from heavy traffic, industrial emissions, waste burning, and poor waste management, of which the Kejetia market is not an exception.

Kejetia market in Kumasi is not just a marketplace; it's the heartbeat of the Ashanti Region and one of the largest indoor markets in West Africa, where thousands of vendors and shoppers fill its alleys daily.[7] Kejetia's unique combination of gridlocked traffic, non-stop commerce, and substantial waste creates perfect conditions for dangerous air pollution levels.

Despite Kejetia market's regional importance, it lacks comprehensive data about its air quality, particularly regarding $PM_{2.5}$, PM_{10}, SO_2, and CO levels. Several air quality-related studies have been conducted in Kumasi.[3,8] Research specifically targeting the Kejetia market is limited. This study primarily aims to evaluate the air quality at the Kejetia market by measuring the concentrations of CO, SO_2, $PM_{2.5}$ and PM_{10} and their potential health risk. This research will provide critical insights into potential health risks faced by merchants, customers, and nearby residents. Educate market users and the general public to understand the importance of clean air and the urgent need for collective action to reduce pollution levels. The findings will also serve as a valuable resource for regulators and policymakers, enabling them to develop targeted, data-driven interventions to improve air quality. Ultimately, contributing to the attainment of Sustainable Development Goal [SDG] 3 (Good Health and Well-being) and SDG 11 (Sustainable Cities and Communities).

MATERIALS AND METHODS

Study Area

The study took place in Kejetia Market in Kumasi Metropolitan Assembly, Ashanti Region. It sits right in the bustling centre of Kumasi, Ghana. The semi-enclosed layout and limited airflow make it particularly interesting for studying how pollutants build up in the air.[9] Key characteristics of the study area include: Geographical Coordinates of Latitude 6.6911° N, Longitude 1.6164° W, Population Density of Over 10,000 traders and commuters daily and also serve as a major transportation hub with high emissions from vehicles (Figure 1).

Research Design

A cross-sectional descriptive research design was adopted for this study to capture a snapshot of air pollutant levels at the Kejetia Market in Kumasi during the non-harmattan season. This design was considered appropriate because it enabled the assessment of air quality parameters at a specific point in time, thereby providing a comprehensive understanding of the existing pollution levels and their potential health implications. The approach also allowed for the comparison of the measured concentrations with international air quality standards established by the United States Environmental Protection Agency (US EPA) and the World Health Organisation.[11]

Quantitative methods were employed to ensure the collection of accurate, objective, and reproducible data on air quality indicators such as particulate matter and gaseous pollutants. The design further facilitated the analysis of spatial variations within the market area, contributing to an evidence-based assessment of the air quality status in relation to human exposure and environmental health risks.[12]

Sampling Techniques and Sample Size

Air quality measurements were obtained from three strategic locations within the central part of the Kejetia Market: Bus Terminal 1, Bus Terminal 2, and a non-bus terminal on the ground floor. Each location was continuously sampled over a 24-hour cycle for thirty-six consecutive days to capture both working and non-working hour variations.

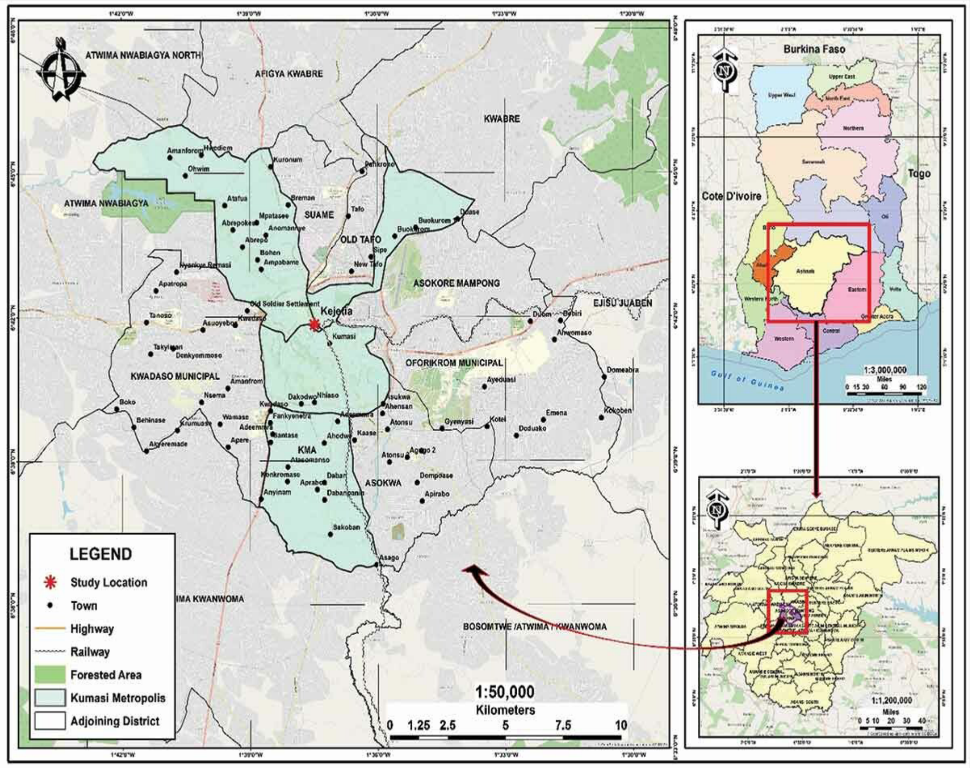

Figure 1. Kumasi locating Kejetia market

Source: Ashanti Regional Analytical Report (Service, 2014), Ghana Statistical Service (2013)[10]

The Kejetia Market is segmented into three main zones (Zone 1 – Ground Floor, Zone 2 – First Floor, and Zone 3 – Second Floor). Zone 1, which accommodates vehicular activities, hawkers, shops, and offices, was selected for the study because it represents the characteristics of the upper zones while having higher exposure to vehicular emissions.

Two instruments were employed: the Haz-Dust Environmental Particulate Air Monitor for $PM_{2.5}$ and PM_{10}, and the Aeroqual Series 500 Multi-Gas Monitor equipped with electrochemical sensors for SO_2 and CO. The instruments were stationed at Bus Terminal 1 for twelve days, during which $PM_{2.5}$ and PM_{10} were each sampled for six days using the Haz-Dust monitor, while SO_2 and CO were sampled for six days each using the Aeroqual device. The same procedure was replicated for Bus Terminal 2 and the non-bus terminal.

This sampling strategy was informed by literature indicating that particulate matter and gaseous pollutants such as SO_2 and CO are largely attributable to vehicular emissions.[11] The air sampling devices were positioned at heights between 1.5 m and 2 m above ground level, representing the human breathing zone and placed away from walls or structures to minimise interference. The devices recorded pollutant concentrations at one-minute intervals over each 24 hours.

Routine checks were performed daily to correct potential instrument malfunctions and ensure data integrity. All measurements were stored in the instruments' internal memory for subsequent download and analysis. The data collected were entirely quantitative.

A total of 108 sampling cycles were completed, generating comprehensive pollutant datasets for statistical and comparative analysis.

Data Analysis Techniques

Quantitative data collected from the study were analyzed using STATA version 15 and Microsoft Excel 2016. The analytical procedures involved both descriptive and inferential statistical methods. Descriptive statistics, including the mean, standard deviation, and range, were computed to summarize pollutant concentrations across the three sampling locations.

The Kolmogorov–Smirnov normality test was conducted to assess the distribution of pollutant concentration data and determine the suitability of subsequent statistical tests. The Air Quality Index (AQI) model, as recommended by the United States Environmental Protection Agency (US EPA), was applied to evaluate potential health risks associated with exposure to the measured pollutants. The observed pollutant concentrations were further compared with the World Health Organisation (WHO) air quality guideline limits to assess compliance and potential exceedances.

To examine the relationship between pollutants at the three sampling sites, Pearson's correlation coefficient was applied for normally distributed data, while Spearman's rank correlation was used for non-normally distributed data. All statistical analyses were performed using two-tailed tests at a 95% confidence level and a significance threshold (α) of 0.05.

Validity and Reliability

To ensure validity, all measuring instruments were carefully calibrated before data collection to guarantee accurate and consistent pollutant readings. In addition, a pre-test of the sampling procedures was conducted to verify the suitability of the instruments and to refine the data collection process.

The reliability of the study was enhanced through repeated measurements at each sampling point to minimise random errors and ensure consistency across observations. Furthermore, triangulation with relevant secondary data sources was performed to cross-check and confirm the accuracy of the primary data collected.[13]

Ethical Considerations

Ethical approval for the study was obtained from the Kwame Nkrumah University of Science and Technology (KNUST) Research Ethics Committee. In addition, written permission was sought and obtained from the Kejetia Market management and relevant authorities before data collection. All research activities were conducted in accordance with institutional ethical guidelines, ensuring respect for participants, property, and the study environment.

Limitations of the Study

The study was conducted over a period of slightly more than one month, which may have limited the ability to capture seasonal variations in air quality, particularly across different climatic periods. Additionally, instrumental sensitivity and calibration constraints may have introduced minor measurement errors during data collection. External environmental factors such as weather conditions, wind direction, and speed could also have influenced pollutant dispersion patterns and, consequently, the recorded concentrations.

RESULTS AND DISCUSSION

Concentrations of $PM_{2.5}$, PM_{10}, SO_2 and CO

$PM_{2.5}$ Concentrations

The concentration of $PM_{2.5}$ was high at 0.64 mg/m³ (SD = 0.58) in the non-Terminal Bus Area, slightly lower than that recorded in Bus Terminal One, which recorded 0.60 mg/m³ (SD = 0.48). Bus Terminal Two had the lowest concentration, at 0.54 mg/m³ (SD = 0.56) (Table 1). The concentration of $PM_{2.5}$ across the selected areas exceeded the WHO guideline of 0.005 mg/m³, strongly suggesting a serious air quality issue in all sites, indicating that non-terminal areas are not substantially better in this case. The elevated $PM_{2.5}$ levels reflect emissions from idling diesel vehicles, road dust resuspension, and poor ventilation. Similarly high values were reported by Amegah and Agyei-Mensah[14] and Nyarko et al.[15] in Ghanaian transport hubs, underscoring the persistent nature of urban particulate pollution. These high concentrations likely stem from intense vehicular emissions, frequent idling, and the resuspension of road dust caused by bus and pedestrian movements. Poor atmospheric dispersion due to crowding and architectural enclosure within the terminals also contributed to pollutant accumulation.

The results corroborate findings by Pope et al.[16], who identified transport hubs as hotspots for $PM_{2.5}$ due to fossil fuel combustion and traffic density. Similarly, Nyarko et al.[15] confirmed vehicular emissions as the dominant particulate source in Ghanaian cities, while Amegah & Agyei-Mensah[14] emphasized $PM_{2.5}$ as a major environmental risk factor for non-communicable diseases in Ghana. Thus, the results confirm that $PM_{2.5}$ pollution at Kejetia poses a severe public health concern consistent with global and local patterns.

PM_{10} Concentrations

PM_{10} concentrations were 0.69 mg/m³ (690 μg/m³) (SD = 0.49) at Bus Terminal One, 0.62 mg/m³ (620 μg/m³) (SD = 0.57) at Bus Terminal Two, and 0.78 mg/m³ (780 μg/m³) (SD = 0.53) at the non-Bus Terminal (Table 1). All sites exceeded the WHO 24-hour guideline of 0.045 mg/m³ (45 μg/m³).

This persistent exceedance may be attributed to vehicular exhaust emissions, brake and tire wear, and resuspension of coarse dust particles. At the non-Bus Terminal, open-air trading, construction activities, and pedestrian traffic also contribute to coarse particulate levels.

The observed trend aligns with Alli et al.[17], who reported similar PM_{10} exceedances at bus depots and transport nodes globally. Nyarko et al.[15] also recorded high PM_{10} levels in Kumasi's Kejetia Market, linking them to vehicular and commercial activity. The findings thus reaffirm that PM_{10} pollution in urban transport settings is a widespread challenge, with serious implications for respiratory health.

SO_2 Concentrations

Average SO_2 concentrations ranged from 0 mg/m³ at the non-Bus Terminal to 7.28×10^{-5} mg/m³ (0.0728 μg/m³) at Bus Terminal One and 6.02×10^{-5} mg/m³ (0.0602 μg/m³) at Bus Terminal Two (Table 1). These concentrations are far below the WHO 24-hour guideline of 40 μg/m³ and fall within the "Good" category on the AQI scale.

Low SO_2 levels may be attributed to reduced sulfur content in fuels used in Ghana, limited industrial activities in the study area, and rapid atmospheric dispersion of SO_2 in open spaces. However, WHO[11] cautioned that even low-level exposures can cause respiratory irritation and exacerbate asthma. Kim et al.[18] similarly observed increased hospital admissions following exposure to low but recurrent SO_2 levels, while Odum et al.[19] highlighted episodic combustion-related risks.

Although the concentrations recorded here appear safe by AQI standards, the findings support the notion that periodic SO_2 exposure in dense urban centres still poses significant health risks.

CO Concentrations

CO levels averaged 7.23 mg/m³ at Bus Terminal One, 6.58 mg/m³ at Bus Terminal Two, and 0.52 mg/m³ at the non-Bus Terminal (Table 1). The two bus terminals exceeded the WHO 24-hour guideline of 4 mg/m³, whereas the non-Bus Terminal remained below this limit.

The elevated CO levels are primarily due to incomplete combustion from idling engines, congestion, and inadequate ventilation in enclosed terminal spaces. In contrast, the lower CO at the Non-Bus Terminal reflects fewer vehicular emissions and better air dispersion.

These findings align with McGowan et al.[20], who noted high CO levels in global transport hubs due to poor combustion efficiency, and with Owusu and Mensah[21], who reported similar patterns in Accra during peak traffic hours. The U.S. EPA[2] also linked elevated CO exposure to oxygen deprivation, particularly among vulnerable populations such as children and those with cardiovascular diseases.

Table 1. Descriptive Statistics of Air Pollutants ($PM_{2.5}$, PM_{10}, SO_2, and CO) and Meteorological Parameters (Temperature and Relative Humidity) at Bus Terminal One, Bus Terminal Two, and Non-Terminal Bus Area in Kumasi

Parameter	Statistic	Bus Terminal One	Bus Terminal Two	Non-Terminal Bus
$PM_{2.5}$ (mg/m³)	Sample size (n)	4927	5176	3852
	Mean	0.6	0.54	0.64
	Std. Dev.	0.48	0.56	0.58
	Min	5×10^{-4}	6.67×10^{-4}	0
	Max	2.21	5.96	1.42
Temperature (°C)	Mean	28.66	26.83	26.63
	Std. Dev.	2.85	2.48	2.39
	Min	18	16	16
	Max		31	31
Relative Humidity (%)	Mean	54.28	61.72	62.63
	Std. Dev.	10.27	7.1	5.94
	Min	33	48	54
	Max	81	84	88
PM_{10} (mg/m³)	Sample size (n)	5017	5660	2625
	Mean	0.69	0.62	0.78
	Std. Dev.	0.49	0.57	0.53
	Min	5×10^{-4}	8.33×10^{-4}	5×10^{-4}
	Max	2.2	1.69	1.44
Temperature (°C)	Mean	27.31	26.91	27.12
	Std. Dev.	2.7	2.68	2.35
	Min	17	17	18
	Max	31	31	31
Relative Humidity (%)	Mean	62.76	61.76	63
	Std. Dev.	6.17	5.78	6.13
	Min	52	53	56
	Max	81	84	88
SO_2 (ppm)	Sample size (n)	1510	2822	609
	Mean	7.28×10^{-5}	6.02×10^{-5}	0
	Std. Dev.	2.20×10^{-3}	1.76×10^{-3}	0
	Min	0	0	0
	Max	0.08	0.08	0
CO (ppm)	Sample size (n)	1616	1887	596
	Mean	7.23	6.58	0.52
	Std. Dev.	1.75	1.46	0.74
	Min	0	0	0
	Max	7.38	7.94	4.3

Health Risk Evaluation

Air Quality Index (AQI) calculations revealed that $PM_{2.5}$ recorded AQI values of 579.31 µg/m^3, 531.53 µg/m^3, and 611.17 µg/m^3 at Bus Terminal One, Bus Terminal Two, and the Non-Bus Terminal, respectively (Table 2). Similarly, PM_{10} recorded 595.61 µg/m^3, 517.79 µg/m^3, and 695.66 µg/m^3. These values are classified as "Hazardous" on the AQI scale, indicating that the entire population is at risk, with serious health effects likely even for short-term exposure.

This agrees with Cohen et al. (2017), who reported $PM_{2.5}$ as the leading global cause of air pollution-related mortality. Pope et al.[16] found that prolonged PM exposure reduces life expectancy, while Amegah & Agyei-Mensah[14] linked particulate pollution in Ghana to widespread cardiovascular and respiratory complications.

SO_2 AQI values (≤0.0016 ppb) for all the terminals fell within the "Good" range. In contrast, CO AQI values, 23.86 ppm, 21.82 ppm, and 1.70 ppm, for bus terminal one, bus terminal two, and non-bus terminal, respectively, ranged from "Moderate" to "Good," depending on location. This is categorised as "Minimal impact" with health implications as "No effect expected", indicating that AQI-based risk levels vary depending on exposure periods and site characteristics. Despite this, the elevated CO levels in bus terminals remain concerning, especially for workers with chronic exposure. Bhatnagar[22] highlighted that long-term exposure to even low doses of SO_2 and CO can contribute to cardiovascular dysfunction, confirming the cumulative nature of the risks identified in this study.

Table 2. Average Concentrations and Air Quality Index (AQI) Values of $PM_{2.5}$, PM_{10}, SO_2, and CO at Bus Terminal One, Bus Terminal Two, and Non-Bus Terminal Area in Kumasi

		Bus Terminal One		
Parameter	24-hour average (mg/m^3)	24-hour Average (µg/m^3)		AQI Value (µg/m^3)
$PM_{2.5}$	0.6	600		579.31
PM_{10}	0.69	690		595.61
SO_2	24-hour average (mg/m^3)	24-hour average (ppb)	1-hour Average (ppb)	AQI Value (ppb)
	7.28×10^{-5}	2.78×10^{-2}	1.16×10^{-3}	1.66×10^{-3}
CO	24-hour average (mg/m^3)	24-hour average (ppm)	8-hour average (ppm)	AQI Value (ppm)
	7.23	6.31	2.1	23.86
		Bus Terminal Two		
Parameter	24-hour average (mg/m^3)	24-hour Average (µg/m^3)		AQI Value (µg/m^3)
$PM_{2.5}$	0.54	540		531.53
PM_{10}	0.62	620		517.79
SO_2	24-hour average (mg/m^3)	24-hour average (ppb)	1-hour Average (ppb)	AQI Value (ppb)
	6.02×10^{-5}	2.30×10^{-2}	9.57×10^{-4}	1.37×10^{-3}
CO	24-hour average (mg/m^3)	24-hour average (ppm)	8-hour average (ppm)	AQI Value (ppm)
	6.58	5.75	1.92	21.82
		Non-Bus Terminal		
Parameter	24-hour average (mg/m^3)	24-hour Average (µg/m^3)		AQI Value (µg/m^3)
$PM_{2.5}$	0.64	640		611.17
PM_{10}	0.78	780		695.66
SO_2	24-hour average (mg/m^3)	24-hour average (ppb)	1-hour Average (ppb)	AQI Value (ppb)
	0	0	0	0
CO	24-hour average (mg/m^3)	24-hour average (ppm)	8-hour average (ppm)	AQI Value (ppm)
	0.52	0.45	0.15	1.7

Correlation Analysis for PM$_{2.5}$, PM$_{10}$, SO$_2$ and CO

PM$_{2.5}$ Correlation

PM$_{2.5}$ concentrations showed strong positive correlations: r = 0.76 between bus terminal one and two, r = 0.61 for bus terminal one and non-bus terminal, and r = 0.80 for bus terminal two and non-bus terminal (Table 3). These strong and moderate correlations indicate similar exposure dynamics across the sites, with bus terminal two and the non-bus terminal exhibiting nearly identical patterns. This suggests shared pollution sources and consistent socio-demographic exposure groups, particularly among traders and commuters.

PM$_{10}$ Correlation

PM$_{10}$ correlations were weak and mixed; r = -0.18 for bus terminal one and bus terminal two, r = 0.31 for bus terminal one and non-bus terminal, and r = -0.27 for bus terminal two and non-bus terminal (Table 4). The weak or negative relationships suggest heterogeneous pollution dynamics, where dust resuspension and localised activities play varying roles across these sites.

CO Correlation

CO exhibited a strong positive correlation between bus terminal one and bus terminal two (r = 0.72), indicating similar emission characteristics from vehicular sources (Table 5). On the contrary, correlations involving the non-Bus Terminal were weaker (r = -0.25 and r = 0.30), reflecting lower and less consistent CO exposure due to fewer vehicles and better dispersion.

SO$_2$ Correlation

Spearman's rank correlation showed a perfect positive relationship (r = 1.00, $p < 0.001$) between bus terminal one and bus terminal two, confirming identical SO$_2$ emission patterns (Table 6). In contrast, no significant correlation existed with the non-bus terminal due to negligible SO$_2$ values. This outcome reflects the similarity of activities and emissions between the two bus terminals, both characterized by intense vehicular operations.

Table 3. Pearson Correlation Coefficients of PM$_{2.5}$ Concentrations Between Bus Terminals and Non-Bus Terminal Area

PM$_{2.5}$ (mg/m^3)	Bus Terminal One	Bus Terminal Two	Non-Bus terminal
Bus Terminal One	1.00		
Bus Terminal Two	0.76	1.00	
Non-Bus terminal	0.61	0.8	1.00

Table 4. Pearson correlation information on PM10 at the three sampling stations

PM$_{10}$ (mg/m^3)	Bus Terminal 1	Bus Terminal 2	Non-bus Terminal
Bus Terminal 1	1.00		
Bus Terminal 2	-0.18	1.00	
Non-bus terminal	0.31	-0.27	1.00

Table 5. Pearson correlation information on CO at the three sampling stations

CO (mg/m^3)	Bus Terminal One	Bus Terminal Two	Non-bus Terminal
Bus Terminal One	1.00		
Bus Terminal Two	0.72	1.00	
Non-bus Terminal	-0.25	0.30	1.00

Table 6. Spearman's rank correlation information on SO$_2$ at the three sampling

SO$_2$ (mg/m^3)	Bus Terminal One	Bus Terminal Two	Non-bus Terminal
Bus Terminal One	1.00 1510		
Bus Terminal Two	1.00* 1510 0	1.00 282	
Non-bus Terminal	. 609 .	. 609 .	. 609 .

CONCLUSION

This study assessed air quality at two major bus terminals and a non-bus terminal in Kejetia Market, Kumasi, Ashanti Region, focusing on the concentrations of $PM_{2.5}$, PM_{10}, SO_2, and CO, and their associated health risks. The results have been interpreted in light of WHO guideline and AQI standards, as well as socio-demographic realities of exposed populations. The following conclusions are drawn in consonance with the study's specific objectives. $PM_{2.5}$ and PM_{10} concentrations at all three sites far exceeded WHO's 24-hour guideline values. Mean levels of $PM_{2.5}$ ranged from 0.54 to 0.64 mg/m^3 (540–640 $\mu g/m^3$), while PM_{10} levels ranged from 0.62 to 0.78 mg/m^3 (620–780 $\mu g/m^3$). These values place air quality in the hazardous category, underscoring serious public health threats. CO concentrations at the two bus terminals also exceeded WHO guideline, but concentrations at the non-bus terminal fell within the WHO regulatory requirements, while SO_2 levels, though low, exhibited episodic spikes in bus terminals. AQI computations revealed that both $PM_{2.5}$ and PM_{10} consistently fell within hazardous ranges, indicating potential for acute and chronic respiratory and cardiovascular health outcomes. SO_2 and CO exposures were less pronounced in terms of averages, but still significant due to episodic peaks and cumulative exposure risks. Vulnerable groups such as children, the elderly, commuters, and informal traders are at heightened risk of adverse health effects. Correlation analyses revealed strong positive correlation for $PM_{2.5}$ across the terminals, reflecting their shared vehicular and combustion sources. PM_{10} correlations were weaker and heterogeneous, suggesting site-specific dust resuspension dynamics. SO_2 showed a perfect correlation between the two bus terminals, indicating a trace presence of sulfur emissions likely from fuel combustion but negligible presence at the non-terminal site because of the absence of combustion sources, while CO displayed strong alignment between the two bus terminals, also reflecting their shared vehicular and combustion sources but weaker associations with the non-bus terminal location due to probably, diffusion from other sources such as vehicular emissions. The findings underscore that bus terminals, as economic and transport hubs, are hotspots of hazardous air pollution. Exposure risks extend beyond commuters and transport workers to vendors, students, and vulnerable community members in the vicinity. Without urgent interventions, the elevated pollutant levels identified will exacerbate Ghana's burden of air pollution-related morbidity and mortality, especially in rapidly urbanizing centers like Kumasi.

AUTHORS' CONTRIBUTION

L.N.A.S.- Conceptualization, supervision and review of the manuscript; J.S., D.K.O.A. - Conceptualization, collection of literature and analysis and draft of manuscript

FUNDING

The author received no financial support for the research, authorship, and/or publication of this article.

CONFLICT OF INTEREST

The author declares no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

1. Shihab AS. Assessment of air quality through multiple air quality index models–a comparative study. *J Ecol Eng*. 2023;24(4).
2. US Environmental Protection Agency. *National Ambient Air Quality Standards (NAAQS)*. US EPA; 2021.
3. Nkansah FK, Durosimi Belford EJ, Hogarh JN, Anim AK. Assessment of ambient air quality and health risks from vehicular emissions in urban Ghana: a case study of Winneba. *J Air Pollut Health*. 2025;10(1):19-36.
4. Gwala N, Ncube A, Sibanda M. Air pollution in African markets: a multi-city study. *Afr J Environ Sci Technol*. 2020;14(5):123-133.
5. Owusu PA, Asumadu-Sarkodie S, Ameyo P. A review of Ghana's air quality in urban centres. *Renew Sustain Energy Rev*. 2020;127:109852.
6. Asante KP, Osei I, Adjei K, Mensah A. Traffic emissions and particulate matter in Accra: a case study. *Sci Total Environ*. 2021;761:143231.
7. Explore Kumasi. *Discover Kejetia Market in Kumasi: West Africa's largest open-air marketplace*. 2025.
8. Ababio BA, Nkansah MA, Hogarh JN, Agyekum TP, Commeh MK. Gaseous air quality and health risk assessment of high school kitchens in the Kumasi Metropolis. *Environ Adv*. 2024;17:100576.
9. Amoatey P, Omidvarborna H, Baawain M, Al-Mamun A. Air pollution and public health in Africa: a review. *Environ Health Insights*. 2020;14:1-19.
10. Ghana Statistical Service. *2010 Population and Housing Census: National Analytical Report*. Ghana Statistical Service; 2013.
11. World Health Organization. W*HO Global Air Quality Guidelines: Particulate Matter (PM2.5 and PM10), Ozone, Nitrogen Dioxide, Sulfur Dioxide and Carbon Monoxide*. World Health Organization; 2021.
12. Creswell JW. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. 5th ed. SAGE Publications; 2018.
13. Mensah-Amoah P, Arku RE, Zúñiga J. Air quality and health risk assessment in urban market environments: evidence from Ghana. *Int J Environ Res Public Health*. 2019;16(14):2526.
14. Amegah AK, Agyei-Mensah S. Urban air pollution in Sub-Saharan Africa: time for action. *Environ Pollut*. 2018;220(Pt A):738-743.
15. Nyarko BK, Amegah AK, Sowah S. Ambient particulate matter and carbon monoxide in Ghana: levels and sources. *Environ Challenges*. 2021;5:100315.
16. Pope CA, Turner MC, Burnett RT, et al. Relationships between fine particulate air pollution, cardiometabolic disorders, and cardiovascular mortality. Circ Res. 2015;116(1):108-115.

17. Alli AS, Clark SN, Hughes AF, et al. Spatial-temporal patterns of ambient fine particulate matter ($PM_{2.5}$) and black carbon (BC) pollution in Accra. *Environ Res Lett*. 2021;16(7): 074013.
18. Kim H, Kim H, Lee JT, Kim SY. Effect of long-term exposure to sulfur dioxide on mortality and morbidity: a systematic review and meta-analysis. *Int J Environ Res Public Health*. 2019;16(21):4118.
19. Odum JR, Jungkamp TPW, Griffin RJ, Forstner HJL, Flagan RC, Seinfeld JH. The atmospheric aerosol-forming potential of whole gasoline vapor. *Science*. 1997;276(5309):96-99.
20. McGowan J, Smith R, Johnson L. Vulnerable groups, such as children, pregnant women, and individuals with cardiovascular diseases are especially susceptible to the harmful effects of CO exposure. *J Environ Health*. 2020;82(5):24-30.
21. Owusu G, Mensah J. CO exposure and health impacts in Ghanaian markets. *J Environ Health Sci*. 2018;34(6):789-802.
22. Bhatnagar A. Environmental determinants of cardiovascular disease. *Circ Res*. 2017;121(2):162-180.