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Spectroscopic Analysis of Some Air Pollutants in Yola North LGA, Adamawa State, Nigeria

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Abstract: *Air pollution is a significant environmental and public health concern, particularly in urban areas with high vehicular and industrial activity. This study assessed the Concentration levels of Air pollutants using ALTAIR 5X Multigas Detector in Yola Metropolis and evaluated their associated health risks during the rainy season. The pollutants include CO, H_2S and SO_2 at five (5) locations. The locations have the highest concentration of CO as 96.54mg/m^3 at Jimeta Ultra-Modern Market; SO_2 as 83.87ug/m^3 at Jambutu Bye-Pass; H_2S as 0.039ppm at Jambutu Bye-Pass. Results indicated CO concentrations were alarmingly high across all sites, far surpassing safe limits, while SO_2 and H_2S levels also exceeded recommended thresholds, indicating potential respiratory and neurological health impacts. The study highlights the urgent need for regulatory measures, public awareness campaigns, and cleaner energy adoption to mitigate air pollution and safeguard public health. It also showed that dwellers at Jambutu Bye-Pass are high potential health risk, considering the level of pollutants inhaled daily. Anthropogenic activities were discovered to be the major contributor to the level of concentration of air pollutants.*

Keywords: *Air Pollutants, Air Quality, Health Risk Index, Emissions*

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1.0 Introduction

Air pollution is one of the most persistent environmental and public health challenges globally, with far-reaching impacts on ecosystems, economies, and human well-being. The World Health Organization (WHO, 2021) estimates that approximately 7 million premature deaths occur annually due to exposure to both ambient and household air pollution, underscoring its role as a leading environmental risk factor for disease and mortality. Among the most critical pollutants are carbon monoxide (CO), hydrogen sulfide

(H_2S), and sulfur dioxide (SO_2), which, despite differences in chemical behaviour and toxicological pathways, are widely recognized for their potential to impair respiratory, cardiovascular, and neurological health (Abulude et al., 2024; WHO, 2021).

In Nigeria, air pollution is driven predominantly by anthropogenic activities such as vehicular emissions, industrial discharges, domestic generator use, biomass burning, and indiscriminate waste incineration (Yakubu, 2020; Obanya et al., 2018). Carbon monoxide is typically released from incomplete combustion in vehicles, generators, and biomass stoves (Olalekan et al., 2020), while sulfur dioxide arises largely from the combustion of fossil fuels in power plants and refineries (Ibrahim et al., 2018). Hydrogen sulfide, though less studied, is emitted during oil and gas exploration, sewage treatment, and waste degradation (Oluyemi et al., 2018). Previous studies across Nigerian cities have reported alarming pollutant levels. For instance, Adeniran et al. (2024) and Maitera et al. (2017) found that CO concentrations often exceed those of SO_2 and H_2S, primarily due to traffic congestion and poor energy practices.

Despite these efforts, most of the available studies have focused on large metropolitan centers such as Lagos, Abuja, and Port Harcourt, with limited data on smaller but rapidly urbanizing regions like Yola in Adamawa State. Yola North Local Government Area (LGA), in particular, is experiencing increasing population growth, vehicular density, and commercial activity, yet baseline data on air pollutant concentrations and their potential health risks remain scarce. Moreover, little attention has been given to seasonal variations, such as pollutant dynamics during the rainy season, which can influence atmospheric dispersion and exposure levels. This gap in knowledge limits the ability of policymakers and health authorities in the region to implement effective air quality management strategies.

The present study therefore aims to assess the concentrations of CO, SO_2, and H_2S in selected locations within Yola North LGA using spectroscopic analysis with an ALTAIR 5X Multigas Detector. It also seeks to evaluate the associated health risks of exposure to these pollutants during the rainy season.

The significance of this work lies in its potential to provide baseline air quality data for Yola North LGA, which is currently underrepresented in air pollution research. The findings will contribute to scientific understanding of pollutant distribution in semi-urban Nigerian contexts, highlight the role of anthropogenic activities in exacerbating air quality challenges, and support evidence-based interventions such as stricter regulatory policies, cleaner energy adoption, and community-focused health awareness campaigns. By addressing the current data gap, this study aims to guide local and national efforts in safeguarding environmental quality and public health.

1.1 Study Area

Yola Metropolis serves as the capital of Adamawa State, Nigeria. It is situated between latitude 9.2ºN and longitude 12.48ºE. The study area includes Jambutu Bye-Pass (Location 1); Unity Fly-Over (Location 2); Capital Fly-Over (Location 3); Mubi Fly-Over (Location 4) and Jimeta Ultra-Modern Market (Location 5) in Yola North LGA, Adamawa State. A farmland in Kwanan Waya was used as control site, which was neither close to houses nor any main road.

2.0 Materials and Methods

Air pollutant measurements were carried out onsite across selected locations within the study area during peak traffic periods in the evening, when emissions were expected to be highest. A portable ALTAIR 5X Multigas Detector (MSA Safety Inc.) was employed for the monitoring. The device, equipped with electrochemical sensors, automatically measured and recorded the concentrations of carbon monoxide (CO), sulfur dioxide (SO_2), and hydrogen sulfide (H_2S) in real time.

During sampling, the detector was positioned approximately 1.5 meters above ground level, representing the average human breathing zone, and held steady for 10–15 minutes at each location to ensure reliable readings. Monitoring was conducted at regular intervals to capture variations in pollutant levels across the sites. Each measurement campaign was repeated three times during the rainy season (June 2025) to account for temporal fluctuations and improve the reliability of the dataset.

3.0 Result and Discussion

The concentrations of carbon monoxide (CO), sulfur dioxide (SO_2), and hydrogen sulfide (H_2S) measured across the five locations in Yola North LGA are presented in Table 1 and visualized in Figure 1. The results show distinct spatial variations in pollutant levels, with all values exceeding World Health Organization (WHO) recommended limits, thereby posing significant risks to public health. The corresponding risk descriptions from WHO guidelines are summarized in Table 2.

Table 1: Concentrations of CO in the Study Areas

Location	CO (mg/m³ Mean±SD	H_2S (ppm) Mean±SD	SO_2 (ug/m³) Mean±SD
Jambutu Bye-Pass	89.66±0.185	0.039±0.0065	83.87±0.030
Unity Fly-Over	29.77±0.53	0.022±0.0034	41.93±0.027
Capital Fly-Over	14.11±0.027	0.027±0.0021	73.39±0.027
Mubi Fly-Over	61.42±0.020	0.021±0.0025	57.66±0.030
Jimeta Ultra-Modern Market	96.54±0.030	0.031±0.0049	55.04±0.020

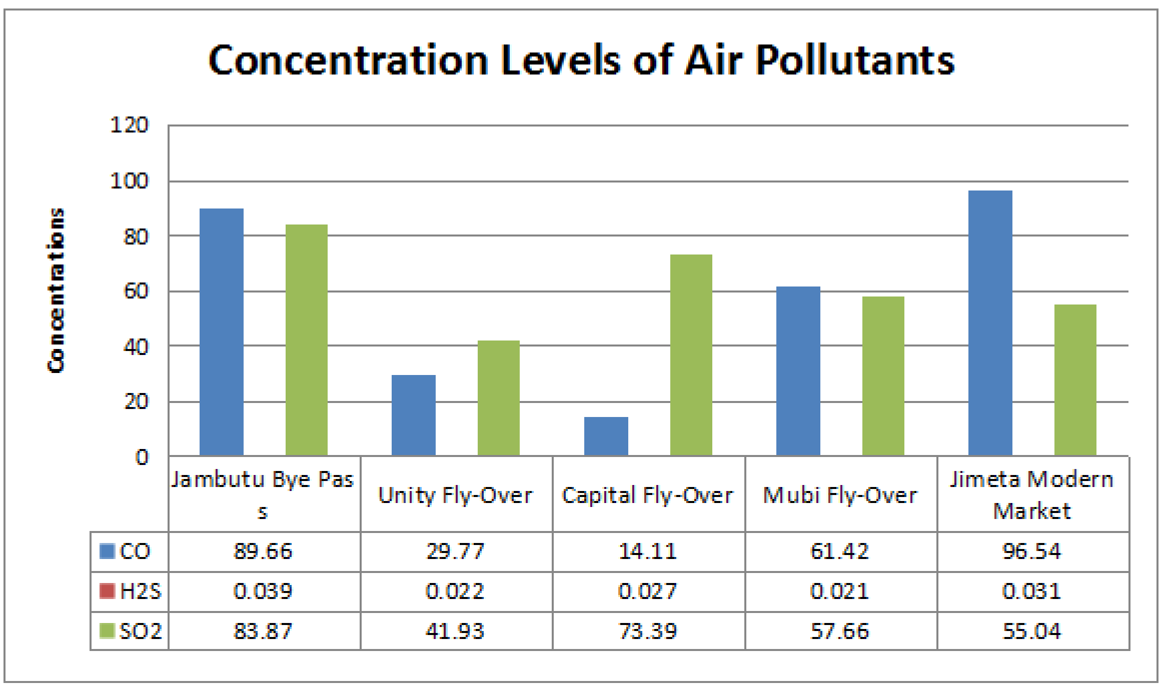

Fig. 1: Concentration levels of Air Pollutants

Table 2: Concentrations, Risks and WHO Risk Description

Location	Jambutu Bye-Pass	Unity Fly-Over	Capital Fly-Over	Mubi Fly-Over	Jimeta Modern Market
CO (mg/m^3)	89.66	29.77	14.11	61.42	96.54
CO Risk	3	3	3	3	3
CO Description	Possible death	Possible death	Possible death	Possible death	Possible death
H_2S (ppm)	0.039	0.022	0.027	0.021	0.031
H_2S Risk	2	2	2	2	2
H_2S Description	Odor nuisance	Odor nuisance	Odor nuisance	Odor nuisance	Odor nuisance
SO_2 (ug/m^3)	83.87	41.93	73.39	57.66	55.04
SO_2 Risk	2	2	2	2	2
SO_2 Description	Short in breath	Short in breath	Short in breath	Short in breath	Short in breath

3.1 Carbon Monoxide (CO)

The distribution of CO concentrations among the study sites followed the pattern: Capital Fly-Over < Unity Fly-Over < Mubi Fly-Over < Jambutu Bye-Pass < Jimeta Ultra-Modern Market. The highest concentration was recorded at Jimeta Ultra-Modern Market (96.54 ± 0.030 mg/m^3), followed closely by Jambutu Bye-Pass (89.66 ± 0.185 mg/m^3), while the lowest concentration occurred at Capital Fly-Over (14.11 ± 0.027 mg/m^3). All recorded values are well above the WHO 24-hour safe exposure limit of 10 mg/m^3, placing them within Risk Category 3 (WHO, 2021), which is associated with reduced oxygen delivery to vital organs, confusion, unconsciousness, and possible death at sustained exposure.

The extremely high concentrations at Jimeta Ultra-Modern Market and Jambutu Bye-Pass can be linked to heavy vehicular traffic, commercial activities, and reliance on petrol-powered generators in the area. The situation at Jimeta is further compounded by recent urban restructuring, including the relocation of GSM traders to the Palluja Market near the Jimeta Shopping Complex, which has increased human and vehicular density in the area. Similar findings were reported by Maitera et al. (2018), who identified Jimeta

Market as the most CO-polluted spot in Yola, while Adediran et al. (2024) recorded lower values for Jimeta, suggesting that the present increase is due to population growth and intensifying commercial activity.

At Jambutu Bye-Pass, the high CO concentration (89.66 mg/m^3) is attributed to emissions from vehicles, metal workshops, and small-scale commercial activities involving grinding machines. The moderately high values at Mubi Fly-Over (61.42 mg/m^3) can be linked to increasing vehicular traffic in recent years, as also observed by Adediran et al. (2024). Although Capital Fly-Over recorded the lowest concentration, its value still exceeded WHO safe limits, indicating that even relatively less congested areas in Yola are affected by severe CO pollution.

These findings highlight that residents, traders, and commuters are exposed to hazardous levels of CO daily, placing them at risk of gradual but potentially fatal health effects, including cardiovascular and neurological complications.

3.2 Sulfur Dioxide (SO_2)

The pattern of SO_2 concentrations was: Unity Fly-Over < Jimeta Ultra-Modern Market < Mubi Fly-Over < Capital Fly-Over < Jambutu Bye-Pass. The highest level was recorded at Jambutu Bye-Pass (83.87 ± 0.030 µg/m³), more than double the WHO threshold of 40 µg/m³ for 24-hour exposure. Unity Fly-Over recorded the lowest concentration (41.93 ± 0.027 µg/m³), which still exceeded the permissible limit.

SO_2 pollution in the study area is primarily associated with the burning of sulfur-containing fuels, emissions from vehicles and generators, and open waste incineration. At Jambutu Bye-Pass, the combination of traffic congestion, open burning of refuse, and emissions from small-scale industries appears to drive the high concentrations observed. According to WHO health risk categories, all sites fall within Risk Category 2, associated with respiratory symptoms such as wheezing, shortness of breath, aggravated asthma, and increased hospital admissions among vulnerable groups.

The findings corroborate those of Ibrahim et al. (2018), who reported that vehicular emissions and fossil fuel combustion are the dominant sources of SO_2 in Nigerian urban centers. The elevated values in Capital Fly-Over (73.39 µg/m³) and Mubi Fly-Over (57.66 µg/m³) suggest that traffic-related emissions remain a consistent source of SO_2 pollution across Yola.

3.3 Hydrogen Sulfide (H_2S)

Hydrogen sulfide concentrations ranged from 0.021 ± 0.0025 ppm at Mubi Fly-Over to 0.039 ± 0.0065 ppm at Jambutu Bye-Pass, following the pattern: Mubi Fly-Over < Unity Fly-Over < Capital Fly-Over < Jimeta Ultra-Modern Market < Jambutu Bye-Pass. Although the concentrations are relatively low compared to CO and SO_2, they exceed WHO short-term limits, placing all sites within Risk Category 2.

At Jambutu Bye-Pass, the highest H_2S levels are linked to emissions from organic waste decomposition, sewage, and microbial activity. Observations during sampling suggested the presence of foul odors, consistent with H_2S pollution. Similarly, the elevated values at Jimeta Ultra-Modern Market (0.031 ppm) may be attributed to poor waste management practices, accumulation of organic refuse, and inadequate drainage systems in densely populated markets.

Health effects of H_2S exposure at these levels include odor nuisance, eye and throat irritation, headaches, and, at higher exposures, respiratory distress (Oluyemi et al., 2018). Although immediate toxicity is unlikely, chronic exposure in crowded urban markets poses risks to both vendors and customers.

3.4 Comparative Assessment and Public Health Implications

The comparative analysis shows that CO poses the greatest health threat, with concentrations far above safe limits across all locations. SO_2 represents a secondary risk, with all values exceeding WHO thresholds and contributing to respiratory morbidity. H_2S, though lower in concentration, still impacts community well-being through odor pollution and long-term irritation risks.

The most polluted sites—Jimeta Ultra-Modern Market and Jambutu Bye-Pass—present the highest combined burden of pollutants, making them priority targets for air quality management. These findings emphasize the role of anthropogenic activities—vehicular emissions, commercial activities, and poor waste management—as key contributors to deteriorating air quality in Yola.

To mitigate these risks, urgent interventions are required, including stricter emission control policies, promotion of renewable energy alternatives, improved waste management, and sustained public health awareness campaigns. Establishing continuous air quality monitoring in Yola will also be essential to provide long-term data for effective regulation and to protect vulnerable populations.

4.0 Conclusion

The findings of this study reveal that air pollutants including carbon monoxide, sulphur dioxide, and hydrogen sulphide are present in concentrations that exceed the World Health Organization's permissible limits across all investigated sites. The highest levels of carbon monoxide were observed at Jimeta Ultra-Modern Market and Jambutu Bye-Pass, largely attributable to high vehicular emissions, population density, and intense commercial activities, while the lowest was recorded at Capital Fly-Over. Sulphur dioxide concentrations were most elevated at Jambutu Bye-Pass, associated with open burning of waste, traffic congestion, and small-scale industrial emissions, whereas Unity Fly-Over recorded the lowest value. Hydrogen sulphide levels were found to be highest at Jambutu Bye-Pass and least at Mubi Fly-Over, with emissions linked to waste decomposition, organic matter decay, and microbial activities. The overall risk assessment indicates that carbon monoxide falls within the highest risk category across all sites, posing serious threats to human health, while sulphur dioxide and hydrogen sulphide present moderate but significant health risks, particularly for sensitive populations.

In conclusion, the persistent exceedance of WHO limits in all locations underscores a severe public health concern, with vehicular emissions, waste burning, and commercial activities serving as the main contributors. The findings highlight that Jimeta Ultra-Modern Market and Jambutu Bye-Pass are hotspots of air pollution in Yola, and thus require urgent intervention.

It is therefore recommended that government and regulatory agencies implement stricter air quality monitoring and enforcement in the study area. Measures such as improved traffic management, promotion of cleaner fuels, restriction of open waste burning, and relocation or regulation of certain commercial activities should be prioritized. Public awareness campaigns should also be intensified to sensitize the population about the dangers of prolonged exposure to these pollutants. Furthermore, continuous environmental monitoring and research should be encouraged to guide policy and ensure sustainable management of air quality in Yola and other urban centers in Nigeria.

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Declaration

Consent for publication

Not Applicable

Availability of data and materials

The publisher has the right to make the data public

Ethical Considerations

The authors declare that all research and development described in this manuscript were conducted with the highest standards of integrity. The project was carried out as a collaborative effort, and all authors involved in the physical construction were voluntary participants who have been appropriately acknowledged.

Competing interest

The authors declared no conflict of interest.
This work was sole collaboration among all the authors

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Contribution of Authors

Idegwu Abel Daniel designed the work and wrote manuscript; Milam Charles supervised the work and partook in writing the manuscript. Usaku Reuben was involved in sample analysis, John Stanley and Joseph Christiana were involved in sample identification.