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Assessment of Gaseous Air Pollutants around Selected Open Dumpsites in Ilorin, Kwara State, Nigeria

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ABSTRACT

Open dumping remains the dominant method of municipal solid waste disposal across many Nigerian cities, yet routine monitoring of the gaseous pollutants these sites release is still uncommon. This study assessed eight gaseous pollutants, carbon monoxide, carbon dioxide, nitrogen dioxide, sulphur dioxide, ammonia, hydrogen sulphide, methane, and volatile organic compounds, around three open dumpsites in Ilorin metropolis, Kwara State, Nigeria, namely Gbagede, Sokoto/Ayekale, and Sango. Readings were taken weekly, morning and evening, across a dry and a wet season, and the data were compared among sites using the Kruskal-Wallis test with Bonferroni corrected comparisons, then checked against air quality and occupational reference values using Wilcoxon signed-rank and chi-square tests. Volatile organic compounds recorded the highest mean concentration (2872.66 ± 3455.55 ppm), followed by methane (81.47 ± 49.20 ppm), while nitrogen dioxide returned the lowest mean (0.19 ± 0.17 ppm). Concentrations differed significantly among the three dumpsites for seven of the eight pollutants, with Sokoto/Ayekale generally recording the highest values and Gbagede the lowest. Against World Health Organization guideline values, nitrogen dioxide exceeded the 24-hour limit in 80.05% of readings and sulphur dioxide in 75.26%, carbon monoxide exceeded its limit in 21.46% of readings, and hydrogen sulphide exceeded its occupational reference in only 1.92% of readings. These findings show that residents and workers around the dumpsites, especially Sokoto/Ayekale, face regular exposure to pollutant levels above recognized health-based guidelines, pointing to the need for stronger waste management and routine air quality surveillance in Ilorin.

Keywords: open dumpsite; gaseous air pollutants; ambient air quality guidelines; Ilorin; municipal solid waste; environmental health

INTRODUCTION

Solid waste generation is rising faster than earlier projections anticipated. The World Bank Group's most recent global assessment put municipal solid waste output at roughly 2.56 billion tonnes in 2022, a volume its 2018 edition had not expected to be reached until 2030, and it projects continued growth as urban populations expand and consumption rises (Cook et al., 2026). Much of this waste, especially across low- and middle-income countries, still ends up in open dumps rather than engineered landfills, where uncontrolled decomposition and periodic burning release a mixture of gaseous pollutants into the surrounding air (Salami & Popoola, 2023). The World Health Organization attributes about 4.2 million premature deaths each year to ambient air pollution, with the greatest share of that burden falling on low- and middle-income countries, and it names improved municipal waste management among the interventions that could reduce this toll (World Health Organization, 2024).

In Nigeria, open dumping continues to be the ordinary method of waste disposal in most cities, and the resulting sites are widely reported to raise concentrations of gases such as carbon monoxide, nitrogen dioxide, sulphur dioxide, ammonia, hydrogen sulphide, methane, and volatile organic compounds well above levels found away from the dumps (Daramola & Makinde, 2024; Ikwebe et al., 2025; Ubouh & Nwawuike, 2016). Ilorin, the capital of Kwara State, has grown rapidly enough that at least ten dumpsites have been officially approved for municipal solid waste disposal within the metropolis(Ibikunle, 2022) and daily waste generation in the city has been estimated at around a kilogram or more per person (Ibikunle, 2021).

Two studies conducted specifically on Ilorin's dumpsites, however, have approached the pollution question through emission inventories and dispersion modelling rather than direct ambient measurement. Popoola et al., (2023) modelled particulate matter and volatile organic compound dispersion from open burning at the Sokoto/Ayekale site alone, and Adeniran et al., (2024) modelled air emissions from open burning across the metropolis and identified Ilorin as the receptor location carrying the greatest impact. Neither study measured the wider set of gaseous pollutants directly at ground level across more than one dumpsite, nor across both the dry and wet seasons, leaving an incomplete picture of what people living and working around these sites are actually being exposed to.

This study addresses that gap by measuring eight gaseous pollutants directly at three dumpsites representing different local government areas within Ilorin metropolis, Gbagede in Ilorin West, Sokoto/Ayekale in Asa, and Sango in Ilorin South, across both seasons of the year. The specific objectives were to determine the concentrations of carbon monoxide, carbon dioxide, nitrogen dioxide, sulphur dioxide, ammonia, hydrogen sulphide, methane, and volatile organic compounds around the three dumpsites, to compare these concentrations among the dumpsites, and to compare the measured concentrations against relevant national and international air quality guideline values, with a view to informing the environmental and public health implications for the surrounding communities.

METHODS

Study Design

This study adopted an observational environmental monitoring design involving repeated measurements of ambient gaseous pollutant concentrations at selected municipal dumpsites within Ilorin metropolis, Kwara State, Nigeria.

Research Areas

The study was conducted at three municipal dumpsites located within Ilorin metropolis, Kwara State, Nigeria. The selected dumpsites comprised the main municipal dumpsite along Sokoto/Aiyekale Road, the Gbagede dumpsite in Amayo (a disused dumpsite), and the Sango dumpsite. These sites are situated within Ilorin West, Asa, and Ilorin South Local Government Areas (LGAs), respectively, thereby providing spatial coverage across different parts of the metropolis. Ilorin metropolis, the capital of Kwara State, is located in the North-Central geopolitical zone of Nigeria. It comprises the urban communities within five Local Government Areas: Asa, Ilorin East, Ilorin South, Ilorin West, and Moro. The metropolis lies between latitudes 8°15′N and 9°10′N and longitudes 4°15′E and 4°50′E, with an average elevation of approximately 300 m above sea level (Figure 1). The study area lies within the transitional ecological zone between the southern Guinea savanna and the forest belt of Nigeria. It experiences a tropical climate characterized by distinct wet and dry seasons, with an average annual rainfall of approximately 1,200 mm, mean monthly temperatures ranging from 25°C to 29.5°C, and relative humidity varying between 32% and 98%. These climatic conditions influence the dispersion, transport, and atmospheric behaviour of air pollutants, making seasonal air quality assessment particularly important. According to the 2006 National Population Census, Ilorin metropolis covers an estimated land area of 3,158.9 km² and has a population of approximately 1,015,317 (Kareem et al., 2022). The three dumpsites selected for this study were chosen to capture variations in waste disposal activities, operational status, and surrounding land-use characteristics across the metropolis, thereby providing a representative assessment of ambient air quality in the study area.

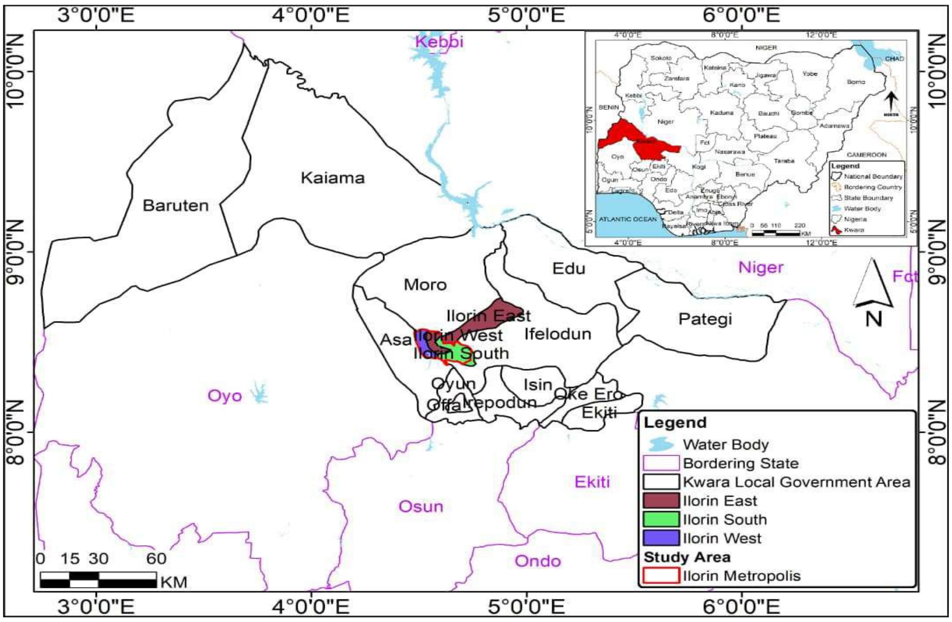

Figure 1: Map of the Study Area (Kareem et al., 2022)

Sampling Location Selection

Three (3) municipal dumpsites within Ilorin metropolis were purposively selected based on their operational characteristics, geographical distribution within the metropolis, waste disposal activities, and accessibility for environmental monitoring. The selected sites comprised the major municipal dumpsite at Sokoto/Aiyekale, the Gbagede dumpsite in Amayo, and the Sango dumpsite. The inclusion of these sites ensured representation of different waste management conditions and surrounding land-use characteristics within the metropolis.

Sample Collection

Ambient air sampling was conducted during both the dry and wet seasons to account for seasonal variations in gaseous pollutant concentrations. Measurements were obtained once weekly over three consecutive months during each season. Sampling was carried out twice daily (morning and evening) to capture diurnal variations associated with changes in meteorological conditions and waste disposal activities. This sampling schedule ensured that the dataset reflected typical exposure conditions experienced by nearby residents and waste workers across different periods of the day and seasons of the year.

Air Sampling Procedure

At each sampling location, gas monitoring instruments were positioned approximately 1.5 m above ground level, representing the average human breathing zone, and away from immediate obstructions that could interfere with airflow. Prior to each measurement, the instruments were allowed to stabilize according to the manufacturers' recommendations before readings were recorded. Ambient concentrations of nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2), hydrogen sulfide (H_2S), oxygen (O_2), volatile organic compounds (VOCs), ammonia (NH_3), and methane (CH_4) were measured in situ using portable real-time gas monitoring instruments. Field observations, including date, time, prevailing weather conditions, and site characteristics, were documented during each sampling session.

Measurement of Gaseous Pollutants

Measurement of NO_2, SO_2, CO, CO_2, H_2S, O_2 and VOCs

NO_2, SO_2, CO, CO_2, H_2S, O_2, and VOCs were measured using an MSA Altair 5X Multigas Detector. The instrument uses electrochemical sensors for applicable gases and a photoionization detector (PID) for VOC measurement and provides real-time digital readings, including STEL, TWA, and peak concentrations. Fresh-air zero calibration was performed before field measurements. The measurement ranges were NO_2 (0–20 ppm;

resolution 0.1 ppm), SO_2 (0–20 ppm; resolution 0.1 ppm), CO (0–300 ppm; resolution 1 ppm), CO_2 (0–300 ppm; resolution 1 ppm), H_2S (0–200 ppm; resolution 1 ppm), O_2 (0–30% volume), and VOCs (0–100 ppm). Following stabilization, the readings were recorded directly from the instrument display.

Measurement of NH_3 and CH_4

NH_3 and CH_4 were measured using an Eagle 2 Multi-Gas Detector, which provides continuous digital readings and STEL, TWA, and peak values, with audible, visual, and vibration alarms. Fresh-air auto-zero calibration was performed before each monitoring session. NH_3 was measured over a range of 0–100 ppm, while CH_4 was measured over a range of 0–10% Lower Explosive Limit (LEL). Measurements were recorded after instrument stabilization under ambient field conditions.

Calibration and Quality Assurance/Quality Control

The MSA Altair 5X was calibrated using a multi-step procedure. A fresh-air zero calibration was first performed to establish the sensor baseline. Span calibration was subsequently performed using the appropriate certified calibration-gas mixture. The span-gas concentrations programmed into the instrument were verified against the certified gas concentrations before application. Calibration gas was delivered using a demand-flow regulator through a C10 connection. The gas was applied until the sensors reached the required response criterion, with the T90 response time used to assess sensor response to 90% of the final calibration-gas concentration. The span-calibration procedure was performed twice to confirm consistent sensor response. A bump test was subsequently conducted to verify sensor response and the proper functioning of the audible, visual, and vibration alarms.

Fresh-air auto-zero calibration was performed before each monitoring session, and the instruments were routinely inspected for sensor functionality, battery status, and general operational condition. Standardized procedures were used for instrument positioning, stabilization, measurement, and data recording at all sites. Field records included sampling date, time, season, prevailing meteorological conditions, and site observations. Data were reviewed for completeness, transcription errors, implausible values, and instrument-related anomalies before analysis.

Meteorological Conditions

Meteorological conditions were recorded during each sampling session because temperature, relative humidity, wind conditions, and rainfall can influence pollutant dispersion and accumulation. The prevailing weather condition at the time of each measurement was documented alongside the pollutant concentrations, sampling date, and time. These observations were considered when interpreting differences in pollutant concentrations between sampling periods and seasons

Statistical Analysis

Data were cleaned and analysed using IBM SPSS Statistics version 27 and Python version 3.11. During data cleaning, pre-aggregated ("Mean") rows were excluded, and a small number of observations for SO_2, NH_3, CH_4, and VOC from the Sokoto/Ayekale dumpsite collected during the wet season (May) were omitted because of documented data quality issues identified during field verification. Descriptive statistics (mean, standard deviation, median, interquartile range, minimum, maximum, frequencies, and percentages) were used to summarize gaseous pollutant concentrations. Normality and homogeneity of variances were assessed using the Shapiro–Wilk and Levene's tests, respectively. Since the data did not satisfy the assumptions for parametric analysis, differences in pollutant concentrations among the dumpsites were evaluated using the Kruskal–Wallis H test, followed by Bonferroni-adjusted Mann–Whitney U tests for pairwise comparisons where appropriate. Measured concentrations were compared with applicable reference values using the one-sample Wilcoxon signed-rank test, while chi-square tests of independence were used to compare the proportions of measurements exceeding reference values among the dumpsites. Pollutants without established reference values (CH_4 and VOC) were excluded from these comparisons. Statistical significance was established at $p < 0.05$.

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Ethical Considerations

Ethical approval for the study was obtained from the Kwara State University Ethical Review Committee before commencement of fieldwork. Permission to access and conduct air quality monitoring at the selected municipal dumpsites was obtained from the relevant waste management authorities and local government authorities responsible for the study sites. All field activities were conducted in accordance with standard occupational health and safety procedures to ensure the safety of the research personnel during environmental monitoring.

RESULTS

Concentrations of the Selected Gaseous Pollutants Around the Dumpsites

Table 1 presents the overall descriptive statistics of the eight gaseous pollutants, pooled across all three dumpsites. Mean concentrations ranged from 0.19 ± 0.17 ppm for NO_2 to 2872.66 ± 3455.55 ppm for VOC.

Table 1: Descriptive Statistics of Gaseous Pollutant Concentrations (ppm), Pooled Across Dumpsites

Parameter	N	Mean ± SD	Median (IQR)	Min-Max
CO	424	3.13 ± 6.38	1.00 (3.00)	0.00-42.00
CO2	424	175.00 ± 146.95	200.00 (300.00)	0.00-600.00
NO2	416	0.19 ± 0.17	0.20 (0.20)	0.00-1.00
SO2	384	0.53 ± 0.86	0.20 (0.53)	0.00-5.70
NH3	384	0.32 ± 0.35	0.20 (0.30)	0.00-1.70
H2S	416	1.93 ± 2.42	1.00 (2.00)	0.00-17.00
CH4	384	81.47 ± 49.20	90.00 (77.00)	0.00-215.00
VOC	384	2872.66 ± 3455.55	2000.00 (2500.00)	0.00-55000.00

Note. N = number of individual Point A-D / single-location readings retained for analysis, after excluding pre-aggregated 'Mean' rows and the documented Sokoto/Ayekale Wet-season-May exclusion (CH4, SO2, VOC, NH3 only). SD = standard deviation; IQR = interquartile range.

Comparison of Gaseous Pollutant Concentrations Among the Selected Dumpsites

Shapiro-Wilk tests indicated that all eight pollutants departed from a normal distribution in at least one dumpsite ($p < 0.001$ in nearly every case), and Levene's test indicated unequal variance across dumpsites for all eight pollutants. The Kruskal-Wallis H test was therefore used to compare concentrations among dumpsites for each pollutant, followed by Bonferroni-corrected Mann-Whitney U pairwise comparisons where the omnibus test was significant (Table 2). The omnibus test was significant for seven of the eight pollutants; only CO_2 did not differ significantly among dumpsites ($H = 4.72$, $p = 0.095$). Figure 2 shows NO_2 exceedance rate.

Table 2: Mean and ±SD Comparison of Gaseous Pollutant Concentrations Among Dumpsites

Parameter	Gbagede	Sokoto/ Ayekale	Sango	H (df=2)	p	Significant Pairwise Differences
CO	0.55 ± 0.85	5.45 ± 8.63	4.40 ± 3.44	153.17	< 0.001	Gbagede-Sokoto; Gbagede-Sango
CO_2	156.25 ± 135.61	186.46 ± 145.16	210.00 ± 193.22	4.72	0.095	None (omnibus n.s.)
NO_2	0.12 ± 0.10	0.25 ± 0.20	0.18 ± 0.11	54.78	< 0.001	Gbagede-Sokoto; Gbagede-Sango
SO_2	0.18 ± 0.19	1.01 ± 1.14	0.22 ± 0.33	84.16	< 0.001	Gbagede-Sokoto; Sango-Sokoto
NH_3	0.17 ± 0.11	0.56 ± 0.44	0.08 ± 0.10	125.24	< 0.001	All three pairs

H_2S	1.09 ± 1.16	2.95 ± 3.04	0.78 ± 1.04	74.64	< 0.001	Gbagede-Sokoto; Sango-Sokoto
CH_4	82.62 ± 54.01	84.81 ± 44.84	57.88 ± 31.26	6.51	0.039	Sango-Sokoto
VOC	2125.00 ± 1366.20	3597.50 ± 2758.29	3734.38 ± 9490.22	21.27	< 0.001	Gbagede-Sokoto

Note. Gbagede = Gbagede Dump Site, Amayo. H = Kruskal-Wallis test statistic; p = unadjusted omnibus p-value. Significant pairwise differences are based on Bonferroni-corrected Mann-Whitney U tests (α = .05) and are reported only where the omnibus test was significant.

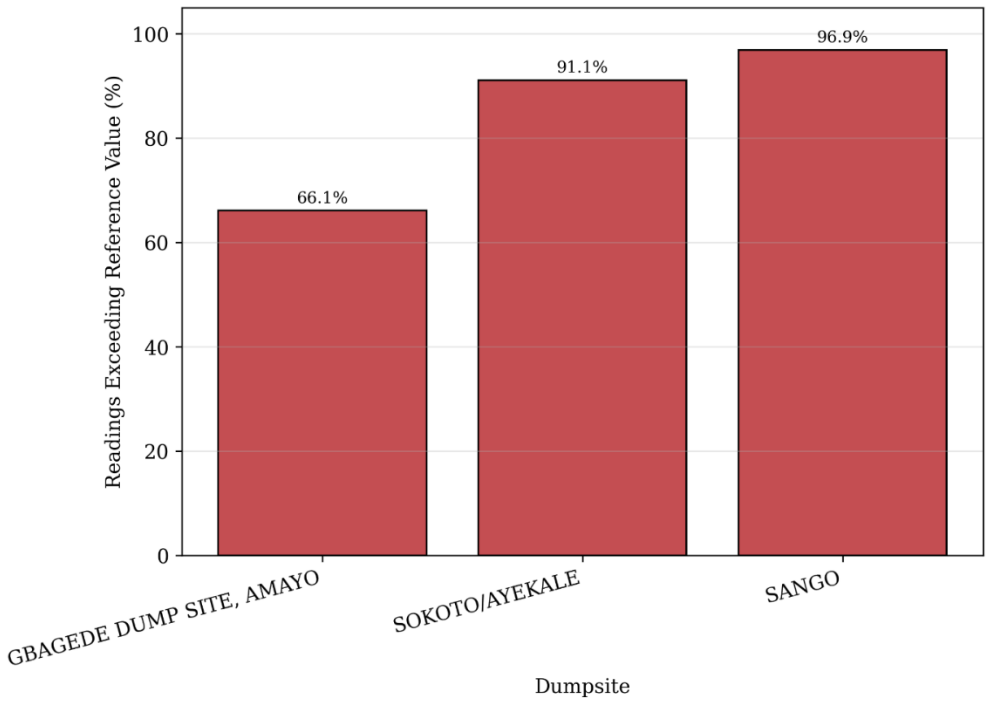

Figure 2. NO_2 concentration (ppm) by dumpsite, with mean values marked and the WHO 24-hour Air Quality Guideline shown as a reference line.

Comparison of Measured Concentrations With Air Quality Guideline Values

Measured concentrations were compared with reference values drawn from the World Health Organization, (2021) Global Air Quality Guidelines (CO, NO_2, SO_2), converted to ppm, or, where no ambient guideline exists, from occupational exposure limits (NH_3, H_2S) or an indoor-air comfort reference (CO_2), each labelled accordingly. No defensible ambient or occupational reference value could be verified for CH_4 or VOC and these two pollutants are therefore reported as not applicable (NR) in Table 3. One-sample Wilcoxon signed-rank tests compared sample values against each reference value, and chi-square tests of independence compared the exceedance proportion among the three dumpsites where variation across sites was present. Figure 3 shows SO_2 readings exceeding the WHO 24-hour Air Quality Guideline by dumpsite.

Table 3: Comparison of Gaseous Pollutant Concentrations With Reference Values

Parameter	**Reference Value (ppm)**	**n Exceeding (%)**	**Wilcoxon V**	**p**	**χ^2 (df) by Site**	**p**
CO	3.49 (WHO 24-h AQG)	91 (21.46)	25417.00	< .001	97.85 (2)	< .001
CO_2	1000 (ASHRAE indoor comfort)	0 (0.00)	0.00	< .001	NR	NR
NO_2	0.0133 (WHO 24-h AQG)	333 (80.05)	3486.00	< .001	43.71 (2)	< .001
SO_2	0.0153 (WHO 24-h AQG)	289 (75.26)	4560.00	< .001	23.56 (2)	< .001
NH_3	25.0 (NIOSH REL, occupational)	0 (0.00)	0.00	< .001	NR (no variability)	NR

H_2S	10.0 (NIOSH REL, occupational)	8 (1.92)	219.00	< .001	9.52 (2)	.009
CH_4	NR	NR	NR	NR	NR	NR
VOC	NR	NR	NR	NR	NR	NR

Note. AQG = Air Quality Guideline (WHO, 2021). NIOSH REL values are occupational exposure limits, not ambient community-exposure standards. NR = not reported: no defensible reference value was available (CH_4, VOC), or the chi-square test was not computable because every reading fell on one side of the reference value (CO_2, NH_3). Full descriptive statistics for CH_4 and VOC are reported in Table 1.

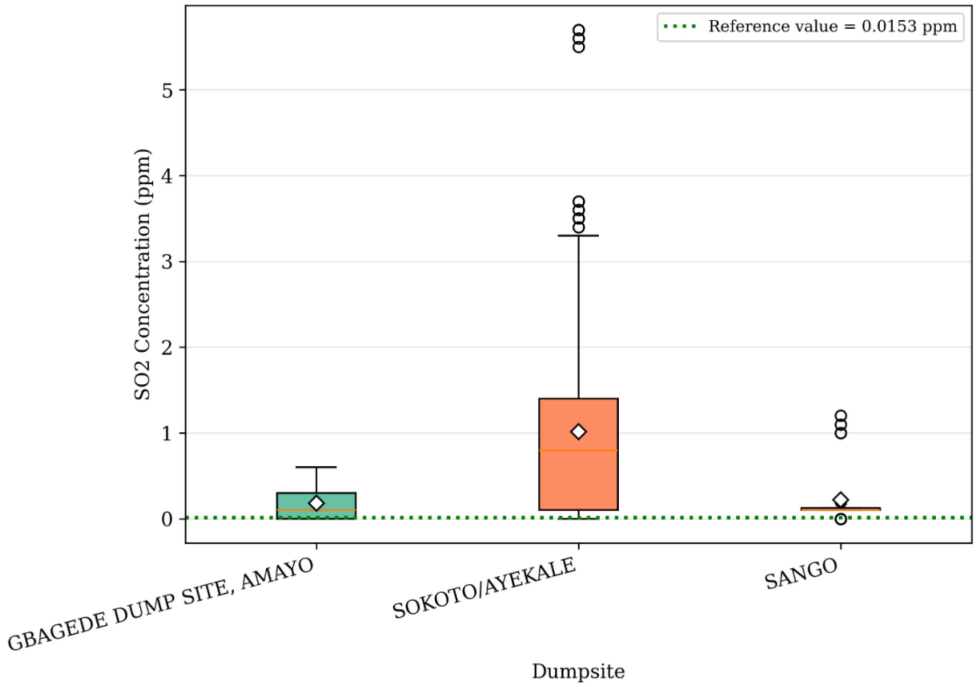

Figure 3. SO_2 readings exceeding the WHO 24-hour Air Quality Guideline by dumpsite.

DISCUSSION

Mean concentrations were highest for VOCs (2872.66 ± 3455.55 ppm) among the eight pollutants analyzed and second-highest for methane (CH_4) (81.47 ± 49.20 ppm), while NO_2 recorded the lowest mean concentration (0.19 ± 0.17 ppm). Weli & Adekunle, (2014) similarly identified VOCs as prominent gaseous emissions in the vicinity of the Rumuolumeni landfill site in Port Harcourt. Kumar et al., (2019) also reported methane as the dominant landfill gas around multiple municipal dumpsites, noting the presence of VOCs including benzene in nearby ambient air. Rahman et al., (2026) recently observed considerable concentrations of benzene, toluene, ethylbenzene, xylene, NH_3, H_2S, SO_2, and NO_2 around the Sarimukti open dumpsite in Indonesia. The high VOC concentration observed in this study may be related to the varied composition of municipal waste, which can include plastics, packaging material, decomposing organic material, as well as open burning at dumpsites. Volatile organic compounds can be released through thermal decomposition and incomplete combustion of solid waste (Elehinafe et al., 2022). The inability to differentiate between VOC species is a limitation of the present study because total VOCs were measured rather than individual chemicals.

Concentrations of seven of eight pollutants differed significantly among the three dumpsites. Sokoto/ Ayekale consistently recorded significantly highest concentrations of CO, SO_2, NH_3, H_2S, and VOCs, while Gbagede consistently recorded significantly lowest concentrations of CO, NO_2, and NH_3. Gbagede is the oldest dumpsite and is currently inactive. Ikwebe et al., (2025) reported significantly higher concentrations of NO_2, SO_2, and CO at dumpsites within Makurdi compared with adjacent control sites. The consistently higher concentrations recorded at Sokoto/ Ayekale are reasonable because it is the primary active municipal dumpsite, receiving the majority of the waste, and deposition is ongoing with considerable opportunity for decomposition and open burning. In contrast, Gbagede is no longer accepting waste which likely limits combustion and decomposition as well as emissions of these gases. These results suggest that waste management practices including dumpsite activity levels, intensity of waste loading, and overall waste-management practices may determine local air quality impacts.

This pattern also aligns with international studies that describe how gaseous emissions around dumpsites are spatially variable depending on waste activity and meteorological conditions. Raza et al., (2021) reported higher pollutant concentrations in dry season months compared with wet season months while evaluating air pollutants generated from municipal solid- waste management facilities in Lahore. In addition, they identified meteorological variables that were associated with the observed air pollutants. Rahman et al., (2026) found similar relationships between H_2S and temperature, wind speed, pressure, humidity, and other pollutants around the Sarimukti open dumpsite. Meteorological conditions have important implications in this study because they can influence atmospheric dilution and transport as well as accumulation of gases generated from waste deposition and combustion.

Comparison With Air Quality Standards

Comparing the observed concentrations with international and national air-quality standards helps to contextualize the results. NO_2 exceeded WHO's 24-hour air-quality guideline value of 0.0 133 ppm during greater than four-fifths of the measurements taken. During approximately three-quarters of the measurements taken, SO_2 also exceeded its corresponding WHO 24-hour air-quality guideline value of 0.0 153 ppm. The frequency of exceedances demonstrates that exposures were likely common during the study period rather than limited to a few abnormal measurements. Daramola & Makinde, (2024) reported similar elevations around Nigerian dumpsites, with NO_2 and SO_2 concentrations observed well above guideline values around the Olusosun and Solous dumpsites in Lagos. Ubouh & Nwawuike, (2016) observed similar elevations of NO_2 and SO_2 along with methane, H_2S, and NH_3 at the Nekede dumpsite.

Similar studies outside of Nigeria have also reported gaseous pollution near dumpsites that approach or exceed guideline limits. Niloufer et al., (2014) monitored emissions from municipal dumpsites in Vijayawada, India. They observed seasonal differences in CH_4, H_2S, NO_2, CO, and NH_3 concentrations where some pollutants exceeded applicable Indian air quality standards while others remained below guideline values. H_2S was implicated as the source of odor nuisance among residents living near the dumpsites. Raza et al., (2021) reported elevated concentrations of air pollution around MSWMFs in Lahore and found that concentrations were higher in the dry season compared with the wet season. The exceedances observed in the present study are consistent with evidence that uncontrolled waste disposal practices may cause localized adverse air quality.

Surprisingly, CO exceeded its WHO 24-hour air-quality guideline value of 3.49 ppm during only approximately one-fifth of measurements. This occurred less frequently than both NO_2 and SO_2, despite CO having the next-highest mean concentration among the pollutants analyzed. Enokela & Kantiok, (2017) reported that CO concentrations observed at four dumpsites in Makurdi remained below recommended limits. Similarly, Oguntoke et al., (2019) reported air quality index ratings ranging from unhealthy to hazardous at dumpsites located in Abeokuta. The lower exceedance frequency observed during this study may imply that combustion emissions were infrequent or intermittent rather than continuous. However, periodic open burning may still generate short-duration peaks in concentration that would not be reflected during weekly monitoring.

NH_3 did not exceed its occupational reference value of 25 ppm at any site, and H_2S exceeded its occupational reference value of 10 ppm during less than 2% of all measurements. Ayodeji et al., (2017) reported NH_3 as the highest of three different gases sampled around the Ajakanga dumpsite in Ibadan. NH_3 concentrations can clearly vary between waste disposal facilities. Niloufer et al., (2014) observed measurable concentrations of H_2S around municipal solid-waste dumpsites in Vijayawada. They noted that H_2S was the cause of odour nuisance in local residents located near the dumpsites. Low exceedance frequencies among NH_3 and H_2S should therefore be considered in context because the reference values applied were occupational guidelines rather than continuous community health standards.

Methane and VOCs require additional discussion because both substances recorded relatively high concentrations, yet could not be compared to a clearly-defined ambient-air health-based guideline in this study.

Kumar et al., (2019) observed high methane concentrations around municipal dumpsites, particularly along downwind areas receiving airborne methane. Researchers studying emissions around the Awotan dumpsite in Ibadan encountered a similar challenge in identifying a suitable health-based ambient reference value for methane and used the lower explosive limit for safe-workplace assessment (Oladejo et al., 2020). In contrast, Raza et al., (2021) observed much lower ambient concentrations of methane around MSWMFs in Lahore, Pakistan. Methane emissions may therefore vary considerably between waste disposal facilities. A lack of suitable ambient benchmarks limits interpretation of total VOC and methane measurements in regards to potential public health implications.

Potential Health Implications

Elevated concentrations of pollutants observed in this study could have implications for workers who spend extended periods of time working at or near waste dumpsites. Nitrogen dioxide and sulfur dioxide can irritate airways upon inhalation and have been associated with respiratory symptoms especially in susceptible populations. Chronic exposure to elevated NO_2 and SO_2 concentrations around active dumpsites could contribute towards respiratory illness in waste workers. Carbon monoxide is concerning because exposure to elevated concentrations can impair oxygen transport by forming carboxyhaemoglobin in blood. Whereas only about one-fifth of measurements exceeded the 24-hour reference value, intermittent exposures during instances of open burning could cause brief exposures that greatly exceed mean concentrations. This would be particularly relevant for waste workers who may spend large amounts of time working directly next to open burning. Ammonia and hydrogen sulfide can irritate eyes and the respiratory tract when breathed in at sufficiently elevated concentrations. Hydrogen sulfide also produces the characteristic odour many people associate with waste dumps. Hydrogen sulfide can cause neurological effects and respiratory issues when breathed in at high concentrations. Supporting this potential health outcome, researchers in Vijayawada found hydrogen sulfide to be the cause of odour complaints among residents living near waste dumpsites (Niloufer et al., 2014). NH_3 and H_2S concentrations observed here should therefore be interpreted with caution given the use of occupational reference values rather than community ambient standards.

Methane has both environmental impacts because it is a greenhouse gas that contributes to climate change. It also poses safety concerns because it can accumulate in enclosed or poorly ventilated areas and has the potential to reach explosive concentrations. Methane would be expected to be present around actively managed waste facilities because it is a byproduct of anaerobic decomposition of organic material. Safety concerns would likely become more relevant if waste management practices are not improved upon and waste continues to accumulate. Total VOCs represents many different chemicals, each of which could have different toxicological profiles. Some VOCs may cause neurological effects or irritation when inhaled at high concentrations. Benzene is a VOC that has been shown to cause cancer. Benzene was detected around dumpsites by Kumar et al., (2019), while Rahman et al., (2026) observed benzene and other aromatic VOCs in the ambient air surrounding an open dumpsite.

Implications should therefore be made in consideration of not only mean concentrations but also the frequency, duration, intensity, and composition of exposure. Direct exposure would be expected among workers responsible for waste collection, sorting, scavenging, and burning. Nearby residents may experience community exposure depending on their proximity to the dumpsite and local meteorological conditions. The presence of several pollutants also raises concerns about the possibility of co-exposure to multiple air pollutants.

Policy Implications

Findings from this study have direct applicability to environmental management practices in Kwara State. Because Sokoto/Ayekale was the most active dumpsite, sampling efforts revealed the highest concentrations of several pollutants, this site should be prioritized for intervention. Open burning should be prohibited while strategies to promote waste segregation, recycling, composting, and controlled waste disposal should be implemented. Routine ambient air monitoring should be instituted at municipal dumpsites in Kwara State, particularly around active dumpsites like Sokoto/ Ayekale. Sampling should be completed during both dry and wet seasons and should take place during various times of day. Meteorological variables including temperature, relative humidity, wind speed, and wind direction should also be recorded during air sampling. Continuous or higher frequency monitoring would also allow identification of short-term pollution events associated with open burning that may have been missed by weekly sampling.

Environmental regulatory agencies responsible for waste management and enforcement of environmental regulations should be strengthened. In Nigeria, this would include the National Environmental Standards and Regulations Enforcement Agency (NESREA) and environmental authorities in Kwara State. Attention should be paid to educating municipal staff and dumpsite workers about potential impacts of open burning and uncontrolled waste disposal. Guideline values were not readily identified for either total VOCs or methane during the preparation of this manuscript. This highlights a need for improved standards regarding monitoring and management of VOCs and methane around municipal waste facilities.

Limitations of the Study

This study has several limitations that should be considered when interpreting the results. Measurements were made on a weekly basis at fixed intervals rather than through continuous monitoring. As such, short-lived episodes of pollution associated with active burning may not have been captured. This limits the ability to determine whether differences seen between sites were due to variations in meteorological dispersion or true differences in waste deposition activity. Finally, all three dumpsites evaluated in this study were located within the same metropolitan area. The findings observed here may not be generalizable to rural dumpsites or sites located elsewhere in Kwara State or Nigeria that differ in waste volume, climate, and waste-management practices.

CONCLUSION

This study set out to determine the concentrations of eight gaseous pollutants around three open dumpsites in Ilorin metropolis, to compare these concentrations among the sites, and to check them against relevant guideline values. Volatile organic compounds and methane were found in the highest concentrations of the eight pollutants, and concentrations differed significantly among the three dumpsites for all pollutants except carbon dioxide, with Sokoto/Ayekale generally recording the highest levels and Gbagede the lowest. Nitrogen dioxide and sulphur dioxide exceeded the World Health Organization’s 24-hour guideline values in the large majority of readings, carbon monoxide exceeded its own guideline in about a fifth of readings, and hydrogen sulphide rarely exceeded its occupational reference, while ammonia stayed within its own reference throughout. No ambient guideline exists for methane or volatile organic compounds despite both being present in substantial concentrations. These results indicate that people living and working around the dumpsites studied, especially Sokoto/Ayekale, are regularly exposed to several gaseous pollutants at levels above recognized health-based limits. Future work should incorporate continuous or passive monitoring alongside meteorological measurements, extend sampling to additional dumpsites across Kwara State, and pursue the establishment of ambient guideline values for methane and volatile organic compounds to support more complete health risk assessment.

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