Journal of Basics and Applied Sciences Research (JOBASR)
ISSN (print): 3026-9091, ISSN (online): 1597-9962
Volume 3(6) November 2025 Special Issue
DOI: https://dx.doi.org/10.4314/jobasr.v3i6.1s

Assessment of Air Quality Parameters in the Vicinity of Selected Dumpsites in Owerri Metropolis, Imo State Nigeria.

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ABSTRACT
Dumpsites are a major factor that contribute to environmental pollution and risk to human. The research aimed to assess air quality conditions at specific dumpsites in Owerri metropolis, Imo state. The methods used were similar to USEPA prescribed method, with a few minor modifications. Measurements were taken at 6 locations within and near the area, utilizing a range of calibrated handheld air quality monitoring devices at each site, eleven (11) air quality indicators were recorded, including particulate matter (PM2.5 and PM10), hydrogen sulfide (H_2S), ammonia (NH_3), sulfur dioxide (SO_2), methane (CH_4), carbon dioxide (CO_2), carbon monoxide (CO), and nitrogen dioxide (NO_2). The findings indicated that PM2.5 and pm10 were present at all dumpsites. The highest readings for all measured parameters were found at the dumpsites, except for CO, which increased as the distance from the dumpsite grew. The air quality parameters varied as follows: CO ranged from 1.00 to 3.50 mg/m3; CO_2 from 1157.50 to 1407.00; NO_2 from 0.151 to 0.228; and CH_4 from 307.50 to 626.50 mg/m^3. The results further indicated that all parameters were elevated at the dumpsites compared to the control site (Obinze). This study highlights the need for an effective waste management system to reduce air pollution in the area.

Keywords:
Air Quality, Dumpsites,
Owerri Metropolis,
Imo State, Nigeria.

INTRODUCTION

Rapid urban growth has resulted in a notable increase in population and a corresponding rise in waste generation rates (Obruche et al., 2019). Consequently, urban areas produce a significant amount of waste, leading to environmental and human health issues (Umudi, 2011). The ongoing expansion of industrial activities and commerce worldwide in recent decades has also contributed to a higher rate of industrial and urban waste production (Ayodeji, 2012; Umudi et al., 2025). United Nations Habitat Watch, opined that urban populations in Africa are expected to rise significantly over the next 40 years (Akpoveta et al., 2024). Only a few of Nigeria's 36 states have demonstrated a strong commitment to proactively tackle this issue. In Nigeria, over 62 million tons of waste is generated each year (Itodo et al., 2021; Umudi et al., 2025). For instance, the rapid increase in urban population in Imo State, Nigeria, leads to a higher density of developed areas. Consequently, every municipality worldwide must address the daily rise in urban solid waste. Major pollutants from dumpsites include particulate matter like wood, dust, ash and metal shavings, liquid leachate (polluted fluid that can seep or absorb into groundwater & nearby agricultural lands); etc. from very poorly managed landfills; and uncontained dumpsite gases emissions (Ese et al., 2024). Leachate may have volatile organic compounds and heavy metals. However, these pollutants (contaminants) can move through surface waters or aquifers. Dust particles from dumpsites may carry human pathogens (diseases) that can be exposed through contaminated soil and groundwater, or through direct contact (DC) with the dumpsite (Bundela et al., 2010; Clark et al., 2025). According to Białowiec (Obruche et al., 2018; Ekpo et al., 2025), emissions from dumpsites produce an average of 150 m^3 of all these biogas per 103 kg of municipal waste & about 5m^3. These values relate to a compacted landfill (Umudi & Awatefe, 2018; Obruche et al., 2025). The biogas generated should be collected & burned or can alos be utilized as source of energy. Various studies have examined dumpsite emissions in other regions of Nigeria. Additionally, previous research has indicated that dumpsites contribute to environmental pollution (contamination) & risk (Umudi, 2019). This study supports the hypothesis that dumpsites environment are a major source of gas emissions and also lead to environmental contamination (pollution).

How to cite this article: Ndubueze O.C., Aguta C.S., Nwogu O.J. & Dike M.N. (2025). Assessment of Air Quality Parameters in the Vicinity of Selected Dumpsites in Owerri Metropolis, Imo State Nigeria. *Journal of Basics and Applied Sciences Research*, *3*(6)s, 1-9. https://dx.doi.org/10.4314/jobasr.v3i6.1s

MATERIALS AND METHODS

Area of Study

The research was carried out in Owerri, which is the capital of Imo State, and is located in the South East of Nigeria. However, this city is situated between Latitude 6°30'N and Longitude 7°34'E. According to 2019 unauthorized estimates, the area has a population of 633,781 of people and over a total land area of 66 km^2 and with an annual population increase or growth rate of 3.3%. However, the region is anticipated to become one of the largest towns in Nigeria by 2025 (Enete, 2010; Umudi et al., 2025). Its low-lying landscape, flat aids in the rapid physical unblockage development of the area. The general climate is mainly wet tropical based on the Koppen-Geiger classification. Significant economic activities encompass tourism, characterized by a surge in the number of hotels, shopping malls, cinemas, and various recreational facilities, alongside a thriving retail sector and informal enterprises, as well as light manufacturing industries. Favorable weather & climatic conditions have facilitated the growth of these economic endeavors, and the recent increase in such activities has significantly contributed to the rise in waste generation (Erienu et al., 2022).

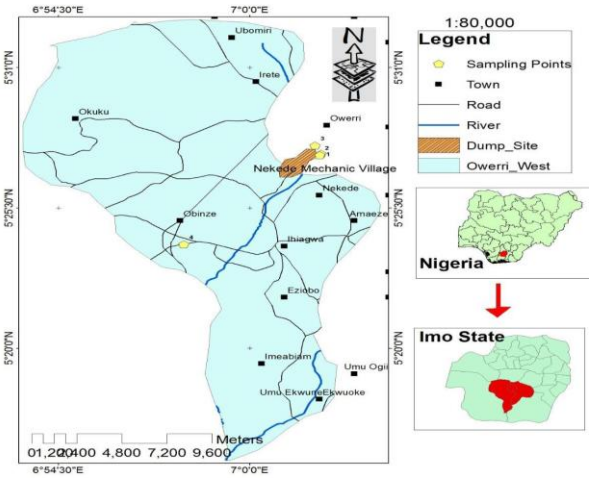

Figure 1: Owerri Map showing waste dumpsite and the sampling stations.

Site Description

The dumpsite designated for gas emission analysis was chosen through random cluster selection based on geographic mapping (WHO, 2010; Ezeah &Roberts, 2012; Umudi et al., 2022). The selected sites included Irete Onitsha road site, Nekéde Mechanic village site, Poly Nekéde site, Egbu road safety site, & Old Nekéde road site & with Obinze serving as the control site. The area of the dumpsites was determined using the eTrex GPS.

Equipment and Materials

The choice of enquipment employed for sample was akin to that of Hughes, (2000) and Festus-Amadi (2021) with some minor adjustments. During this research, the following equipment and instruments were utilized; GPS device: this is a satellite navigation tool commonly referred to as a GPS receiver or simply as a GPS, which calculates geographical positions by receiving data from global navigation satellite systems. In view of this, A GPS device was employed to ascertain longitude, elevation and latitude. However, the handheld GPS map 76 Garmin was utilized for this investigation. Device was utilized to assess wind speed, relative humidity, air pressure, and dew point. Portable Aeroqual Gas Monitor and Sensors: This equipment was implemented to evaluate air quality concerning pollution levels. In this investigation, the Aeroqual Series 500 was utilized. Others include; Nose Mask, Boots, Hand Gloves (Ogwuche and Obruche, 2020; Umudi et al., 2025)

Experimental Procedure

The GPS Map 76 Garmin was employed to determine the locations of the dumpsites (IPCC (2006) and Umudi et al., (2025). Additionally, the eTrex GPS was utilized to measure the area of these dumpsites. The environmental meter, that is the EN100 Extech instrument & was used to monitor and measure the following parameters: air temperature, relative humidity & wind speed. With the assistance of the portable Aeroqual gas monitor and sensors, gas samples were collected from each site. Furthermore, each parameter was measured twice per station at intervals of 30 minutes.

Statistical Analysis

The results obtained were subjected to statistical analysis by utilizing the Statistical Systems software package, employing/using means from triplicate (3) analyses were computed using ANOVA, while standard deviations were determined through the Duncan Multiple Range Test.

RESULTS AND DISCUSSION

Carbon Monoxide Concentration at Dumpsites

According to Table 1, the concentration of carbon monoxide (CO) was highest at the Poly Nekede Road dumpsite, measuring 3.50, while no CO was detected at the control site in Obinze. When compared to the established standards, these levels remain within acceptable limits.

Table 1 carbon monoxide concentration at the dumpsite

Dumpsites	Carbon monoxide (mg/m^3)	FMEnv STD/ Limit
Nekéde old road axis dumpsite	1.00	
Nekéde mechanic axis, dumpsite	1.00	10.00 – 20.00

Poly Nekéde road axis dumpsite	3.50	
Egbu road safety axis dumpsite	2.00	
Irete Onitsha road axis dumpsite	1.70	
Obinzé axis/ Control	ND	

Carbon Dioxide (CO_2) Concentration at Dumpsites

From the results in table 2 on the concentration of 'Carbon dioxide'. The highest concentration of CO_2 was at Nekéde mechanic axis dumpsite site followed by the lowest at Ireté Onitsha road axis dumpsite.

Table 2 carbon dioxide concentration in the dumpsites

Dumpsites	Carbon dioxide(mg/m^3)	IDLH Value
Nekéde old road axis dumpsite	1166.50	
Nekéde mechanic axis dumpsite	1407.00	
Poly Nekede axis dumpsite	1171.00	40,000ppm /72,000mg/m^3
Egbu road safety axis dumpsite	1305.00	
Irete Onitsha axis dumpsite	1157.50	
Obinzé axis / Control	1191.00	

Ozone (O_3) Concentration at Dumpsites

Results from the table 3, the Ozone level/concentration has the highest concentration at Ireté Onitsha road axis and Nekéde old road axis dumpsites. Results were compared with the Federal Ministry of Environmental standard (FMES), all values were below the 2.94 mg/m^3 recommended standard.

Table 3 Ozone concentration in the dumpsites

Dumpsites	Ozone (mg/m^3)	FMEvn STD
Nekéde old road axis dumpsite	0.21	
Nekéde mechanic axis dumpsite	0.18	0.15ppm or 2.94mg/m^3
Poly Nekéde axis dumpsite	0.18	
Egbu road safety axis dumpsite	0.18	
Irete Onitsha road axis dumpsite	0.21	
Obinzé axis /Control	0.19	

Nitrogen Dioxide (NO_2) Concentration at Dumpsites

Table 4 revealed that Irete Onitsha road axis dumpsite had the highest concentration of Nitrogen dioxide. The values are above the environmental recommended standard.

Table 4 Nitrogen dioxide concentration at the dumpsite

Dumpsite	Nitrogen dioxide (mg/m^3)	FMEnv Standard
Nekéde old road axis dumpsite	0.178	
Nekéde mechanic axis dumpsite	0.191	
Poly Nekéde axis dumpsite	0.151	0.04 – 0.06 (1hour)
Egbu road safety axis dumpsite	0.198	
Ireté Onitsha road axis dumpsite	0.228	
Obinzé axis /Control	0.179	

Methane (CH_4) Concentration at Dumpsites

From table 5, the highest concentration of methane was recorded at Nekéde old road axis dumpsite, while no methane was detected in the control site at Obinzé axis. It is also seen that all the values were below the IDLH recommended value.

Table 5 Methane concentration at the dumpsites

Dumpsites	Methane (mg/m^3)	IDLH Value
Nekéde old road axis dumpsite	626.50	
Nekéde mechanic axis dumpsite	591.75	
Poly Nekéde axis dumpsite	326.50	5000ppm / 3280mg/m^3
Egbu road safety axis dumpsite	310.00	
Ireté Onitsha road axis dumpsite	307.50	
Obinze axis /Control	ND	

Hydrogen Sulfide (H_2S) Concentration at Dumpsites
From table 6, it is observed that none of the dumpsites axis exhibited any pollution by Hydrogen Sulfide except Poly Nekéde axis dumpsite. This was above the Federal Ministry of Environmental standard

Table 6 Hydrogen sulfide concentration at the dumpsites

Dumpsites	Hydrogen sulfide (mg/m^3)	FMEnv Standard
Nekéde old road axis dumpsite	ND	
Nekéde mechanic axis dumpsite	ND	
Poly Nekéde axis dumpsite	0.1	0.042 ppm
Egbu road safety axis dumpsite	ND	
Irete Onitsha road axis dumpsite	ND	
Obinze axis /Control	ND	

Volatile Organic Compound (VOC) Concentration at Dumpsites
Results from table 7, it is observed that Nekéde old road axis dumpsite had the highest concentration/level of VOC. It is also safe to note that VOC can create or generate photochemical smog under certain favorable conditions.

Table 7 Concentration of VOCs

Dumpsites	Volatile organic compound(mg/m^3)	FMEnv STD
Nekéde old road axis dumpsite	159.00	
Nekéde mechanic axis dumpsite	98.50	
Poly Nekéde axis dumpsite	63.00	NS
Egbu road safety axis dumpsite	73.00	
Ireté Onitsha road axis dumpsite	64.50	
Obinze axis /Control	56.50	

Sulfur dioxide (SO_2) Concentration at Dumpsites
As shown in table 8, expect for the non-dection (N.D) in Obinzé axis, the value recorded in other sites were above the FMEnv regulatory recommended Standard for 24hrs and 1hr duration.

Table 8 sulfur dioxide concentration at the dumpsite

Dumpsites	Sulfur dioxide (mg/m^3)	FMEnv STD
Nekéde old road axis dumpsite	0.20	
Nekéde mechanic axis dumpsite	0.20	
Poly Nekéde axis dumpsite	0.15	1.01 - 24hrs 0.1 - 1hr
Egbu road safety axis dumpsite	0.15	
Ireté Onitsha road axis dumpsite	0.35	
Obinze axis /Control	ND	

Ammonia (NH_3) Concentration at Dumpsites
As shown in table 9, based on ammonia concentration shows that Nekéde mechanic axis dumpsite was seen the highest concentration of Ammonia. No Ammonia gas was detected at Ireté Onitsha road axis & the control site at Obinzé axis. Comparing the values with the Federal Ministry of Environmental regulation, Nekéde old road axis dumpsite and Nekéde mechanic axis dumpsite are above the recommended standard.

Table 9 ammonia concentration at dumpsites

Dumpsites	Ammonia (mg/m^3)	FMEnv STD
Nekéde old road axis dumpsite	0.9	
Nekéde mechanic axis dumpsite	1.05	
Poly Nekéde axis dumpsite	0.2	0.6 – 24hrs
Egbu road safety axis dumpsite	0.25	
Ireté Onitsha road axis dumpsite	ND	
Obinzé axis /Control	ND	

Particulate Matter (PM_{10}) Concentration at Dumpsites.

As shown in table 10, it is observed that the average concentration of the Particulate Matter (PM_{10}) in the dumpsites axis, only Ireté Onitsha road axis dumpsite was above the recommended limit for the 24hrs duration.

Table 10 concentration of particulate matter (PM_{10})

Dumpsites	PM_{10} (mg/m^3)	FMEnv STD
Nekéde old road axis dumpsite	0.065	
Nekéde mechanic axis dumpsite	0.040	
Poly Nekéde axis dumpsite	0.148	0.15 – 24hrs 0.23 – 1hr
Egbu road safety axis dumpsite	0.029	
Ireté Onitsha road axis dumpsite	0.168	
Obinzé axis /Control	0.016	

Particulate Matter ($PM_{2.5}$) Concentration at Dumpsites

As shown in table 11, it is observed that the highest concentration at Nekéde old road axis dumpsite. Compared to the Federal Ministry of Environmental regulation, the values were below the recommended standard.

Table 11 concentration of particulate matter ($PM_{2.5}$)

Dumpsites	$PM_{2.5}$ (mg/m^3)	FMEnv STD
Nekéde old road axis dumpsite	0.055	
Nekéde mechanic axis dumpsite	0.034	
Poly Nekéde axis dumpsite	0.027	0.15 - 24hrs 0.23 - 1hr
Egbu road safety axis dumpsite	0.025	
Ireté Onitsha road axis dumpsite	0.033	
Obinzé axis /Control	0.014	

This research investigated the various types and concentrations of gas emissions originating from dumpsites in Owerri Metropolis. The findings indicated that the lowest elevation among all evaluated dumpsites was 200.4 feet at the Poly Nekéde axis dumpsite, whereas the highest elevation was recorded at 335.9 feet at the Egbu road safety axis dumpsite. The study demonstrated that carbon monoxide levels were highest at the Poly Nekéde road axis dumpsite, measuring 3.50 mg/m^3. This elevated level may be attributed to the proximity of the site to a busy road, which could lead to potential exposure to carbon monoxide from vehicular traffic and road transport activities. Othman, (2001) and Mughele et al., 2024 suggested that carbon monoxide emissions could increase due to heightened vehicular activity. Additionally, this could be influenced by combustion or incineration activities occurring at the dumpsite (Obruche et al., 2019). When compared to the Federal Ministry of Environment's standard range of 10.00-20.00, the observed levels showed a significant reduction below the standard parameters. A prior study by Onder et al., (2007) and Obruche et al., (2018) which supports the findings of this research, reported carbon monoxide levels of 3.55 mg/m^3 in relation to the standard. According to the study, the Obinzé axis/ Control dumpsite recorded Not Detected and did not contribute any values, likely due to the absence of combustion or incineration activities at that location. Furthermore, the study indicated that carbon dioxide emissions were highest at the Nekéde mechanic axis dumpsite. This result aligns with a study conducted in southern India by Okoh and Trejo-Hernandez, (2006) and Umudi et al., (2025) that focused on gas emissions at landfills. As stated by Onwerenmadu, and Duruigbo, (2007) and Ekpo et al., (2023), ozone gas is formed when nitrous oxides react with other volatile organic compounds (VOCs) in the presence of heat and sunlight. This study revealed, through ozone concentration monitoring, that the Nekéde old road axis dumpsite recorded a level of 0.21 mg/m^3, exceeding the Federal Ministry of Environment's standard of 0.15 mg/m^3. The findings also indicated that the Nekéde mechanic, Egbu road safety, and Poly Nekéde dumpsites each had concentrations of 0.18 mg/m^3, which were closely comparable to the FMEnv standard, while the Irete Onitsha road dumpsite also recorded a concentration of 0.21 mg/m^3. The Obinzé / Control dumpsite recorded an Ozone concentration of 0.19 mg/m3. Individuals situated at the Nekéde Old road dumpsite, where the ozone levels exceed the FMEnv standard, are observed to be at a higher risk for lung diseases, asthma, and other related health issues due to the elevated ozone concentration. In terms of Nitrogen dioxide pollutants, the research indicated that the Ireté Onitsha road dumpsite had the highest concentration at 0.228 mg/m^3. This measurement surpasses the FMEnv Standard range of 0.04-0.06. The increased levels of Nitrogen dioxide in this area are linked to activities such as tobacco smoking, and the burning of gas, wood, and coal. This result contrasts with a prior study conducted in Eastern Nairobi, referenced as (Ukpong & Peter, 2012). The investigation revealed a Methane gas concentration of 626.50 mg/m^3 at the Nekéde old road dumpsite, compared to 310.00 mg/m^3 at Egbu road safety dumpsite and 326.50 mg/m3 at Poly Nekéde axis dumpsite, while the Ireté Onitsha road dumpsite recorded a concentration of 307.50 mg/m^3. The

variations in methane gas levels across these dumpsite locations can be attributed to anthropogenic emission sources present in the vicinity. Sources of the observed methane gas include stationary and mobile combustion systems, oil and gas exploration, industrial activities, and landfills in the area, as noted in reference (Osuji & Chukwunedum, 2001). Following the study's findings, the Obinze axis /Control dumpsite reported no measurable Methane concentration due to a lack of activities associated with methane gas emissions in that area. The research concluded that none of the dumpsites showed any signs of Hydrogen Sulfide pollution, with the exception of the Poly Nekéde axis dumpsite, which had a concentration of 0.1 mg/m^3. This finding is inconsistent with the FMEnv standard of 0.042 mg/m^3. The presence of chemical manufacturing and textile industries in the vicinity may contribute to this situation. Nevertheless, a study referenced as Udosen et al., (2012) and Umudi et al., (2025) indicated a Hydrogen Sulfide concentration of 0.361mg/m^3, which aligns with the findings of this research. A recent article cited as Udo, (2006) suggested that certain solids and liquids with low vaporization energy can release volatile organic compounds (VOCs) as gases at ambient temperature. This investigation determined that the Nekéde old road dumpsite exhibited the highest concentration of volatile organic compounds at 179.00 mg/m^3, while the Obinzé axis/ Control site recorded the lowest concentration at 56.50 mg/m^3. The differences in the concentrations of volatile organic compounds may be attributed to varying industrial activities at the dumpsites. It has been observed that estimates of solid waste disposal rates are linked to the volatility of organic compounds. The research concerning Sulfur dioxide concentrations revealed that the Nekéde old road axis dumpsite had a concentration of 0.20 mg/m3, which is consistent with the Nekede mechanic dumpsite also at 0.20 mg/m3, and slightly higher than the Poly Nekéde axis dumpsite at 0.15 mg/m^3. Conversely, the study indicated that the Egbu road safety dumpsite had a Sulfur dioxide concentration of 0.15 mg/m3, while the Irete Onitsha road dumpsite recorded 0.35 mg/m^3, and the Obinze / Control dumpsite showed no measurable values for this pollutant. The FMEnv standard for Sulfur dioxide is set at 0.01-24 hours, which is not met in these cases. The Sulfur dioxide levels at these sample sites may originate from industrial activities in the area, potentially leading to respiratory disorders, eye irritation, and other health issues. Eye irritations have been associated with gaseous emissions. Ammonia concentrations were found to be highest at the Nekéde mechanic axis dumpsite, measuring 1.05 mg/m3, followed by the Nekéde old road axis dumpsite at 0.9 mg/m3. The Poly Nekéde axis dumpsite recorded Ammonia levels exceeding 0.2 mg/m^3, while the Egbu road safety axis dumpsite had a concentration of 0.25 mg/m^3. In contrast, the Ireté Onitsha road and Obinzé axis /Control dumpsites showed no evidence of Ammonia pollution. In comparison, the dumpsites such as the Nekéde mechanic axis exceed the FMEnv standard of 0.40 for ammonia gas concentration. The detection of ammonia in these dumpsites raises significant concerns, potentially attributable to research conducted by Umanah et al., (2025), which suggested that ammonia interacts with nitrogen oxides, moisture, and other substances to generate particulate matter. The levels of the pollutant Particulate Matter, specifically PM10, in the dumpsites indicated that Obinzé axis/ Control recorded 0.016 mg/m^3, which is marginally aligned with the Federal Ministry of Environment's standard for particulate matter (PM10). The Nekede old road dumpsite exhibited a PM10 concentration of 0.065 mg/m^3, while the Nekéde mechanic dumpsite measured 0.040 mg/m^3. The Egbu road safety axis dumpsite was found to have 0.029 mg/m^3, the Poly Nekéde axis dumpsite recorded a PM_{10} concentration of 0.148 mg/m3, and the Irete Onitsha road axis dumpsite had 0.168 mg/m^3, all in comparison to the FMEnv particulate matter (PM_{10}) standards. According to Obruche et al., (2019) and Ese et al., (2022), particulate matter (PM_{10}) in dumpsite areas consists of solid and liquid particles suspended in the air that are sufficiently small to be inhaled, with their origins stemming from the reactions of various gases in the area with oxides and moisture. The concentration of particulate matter ($PM_{2.5}$) was measured at 0.055 mg/m3 in the Nekéde old road dumpsite, contrasting with a study by Festus-Amadi et al., (2021) conducted at a sample site. The findings indicated 0.034 mg/m^3 in the Nekéde mechanic dumpsite, 0.027 mg/m^3 in the Poly Nekéde axis dumpsite, 0.025 mg/m^3 in the Egbu road safety axis dumpsite, 0.033 mg/m^3 in the Ireté Onitsha road axis dumpsite, and finally, the Obinzé / Control dumpsite recorded $PM_{2.5}$ concentrations of 0.014 mg/m3. This is in relation to the Federal Ministry of Environment's standard for particulate matter ($PM_{2.5}$) of 0.15-24 hours. Nevertheless, the presence of particulate matter ($PM_{2.5}$) raises health concerns for individuals and workers present at the site. This observation contrasts with earlier research conducted by Itodo et al., (2021) and Abeokuta et al., (2025) at open dumpsites in rural India.

CONCLUSION

This research unequivocally illustrates the potential dangers associated with indiscriminate waste collection and disposal within the Owerri municipality. This is alarming due to the presence of nitrous oxide, a gas that depletes the ozone layer, found at some dumpsites in concentrations that exceed the guidelines established by the Federal Ministry of Environment and the World Health Organization (WHO). Similarly, ammonia and particulate matter are also present, both of which contribute to air and water pollution. Considering the elevated wind speeds in the study area, these pollutants

may pose a significant health risk to the densely populated communities in the city. Maintaining a clean air environment is crucial for the survival of human beings, wildlife, and plant life on this planet, as well as for ensuring access to clean water and fertile soil. The gas emission data obtained from this study indicate that levels of nitrous oxide (NO_2) and ammonia (NH_3) significantly surpass the safety limits set by the Federal Ministry of Environment (FMEnv) and WHO standards. Additionally, particulate matter (PM) data revealed elevated concentrations of PM10 (ultrafine particles) and PM2.5 (coarse particles). These findings raise legitimate concerns regarding the air quality in the assessed region. Government should effectively adopt the 'reduce, reuse, and recycle' strategy to ensure that the volume of waste in dumps does not pose a significant environmental threat.

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