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Evaluation of Ambient Air Quality at Selected Dumpsites in Oko and Amaokpala, Southeastern Nigeria

Nwolum Chikezie Fredrick*

Department of civil engineering, Federal Polytechnic, Oko, Anambra State, Nigeria

*Corresponding author: Nwolum Chikezie Fredrick. Department of civil engineering, Federal Polytechnic, Oko, Anambra State, Nigeria.
Email: Nwolum.chikezie@federalpolyoko.edu.ng.

ABSTRACT

This study assessed ambient air quality at three dumpsites in Oko and Amaokpala, southeastern Nigeria. Nitrogen dioxide (NO₂), hydrogen sulfide (H₂S), carbon monoxide (CO), ammonia (NH₃) and sulfur dioxide (SO₂) were measured with a portable multi-gas analyser at the Federal Polytechnic Oko dumpsite, the Abattoir Eke Oko dumpsite and the Amaokpala dumpsite. Six points were sampled at each site, about 1.5 m above ground. Mean CO ranged from 38.42 to 41.49 ppm and mean SO₂ from 0.52 to 1.60 ppm. Abattoir Eke Oko recorded the highest levels (NO₂ 2.05 ppm, H₂S 2.25 ppm, CO 41.49 ppm, NH₃ 13.10 ppm, SO₂ 1.60 ppm). CO, NO₂ and SO₂ exceeded the comparison limits used in the study at all three sites. Open dumping and open burning are the likely sources. Sanitary landfills, a ban on open burning and routine monitoring are recommended.

Keywords: ambient air quality; dumpsite; NO₂; SO₂; carbon monoxide; Oko; Amaokpala

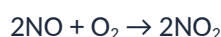
How to cite: Nwolum, C. F. (2026). Evaluation of ambient air quality at selected dumpsites in Oko and Amaokpala, southeastern Nigeria. African Journal of Biological and Physical Sciences, 1(1), Article AFJBPS-2026-011.

1. Introduction

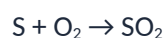
Air pollution is a serious environmental problem in developing countries where waste systems have not kept pace with urban growth. Ambient air quality is the condition of outdoor air with respect to pollutant concentration, and it affects health, ecosystems and quality of life. In many Nigerian communities, population growth, urban expansion and indiscriminate disposal have worsened air quality.

Municipal solid waste has increased with population and changing consumption, while collection and treatment remain inadequate. Open dumping and uncontrolled burning are common. Dumpsites release pollutants through biological decomposition, chemical reaction and combustion. Organic decay produces methane (CH₄), ammonia (NH₃), hydrogen sulfide (H₂S), carbon monoxide (CO), sulfur dioxide (SO₂) and nitrogen dioxide (NO₂).

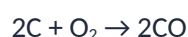
NO₂ is produced by combustion and by decay of nitrogenous waste. High concentrations irritate the lung and reduce pulmonary function. Atmospheric oxidation of nitric oxide is written:



SO₂ is emitted when sulfur-containing waste burns. It contributes to acid rain, corrosion and respiratory illness:



CO is formed by incomplete combustion of plastics, paper and organic waste:



CO binds strongly to haemoglobin and reduces the oxygen-carrying capacity of blood, causing headache, dizziness, fatigue and, at high exposure, death. H₂S is a colourless gas with a rotten-egg odour, produced mainly

by anaerobic decay. Elevated exposure irritates the eyes and can cause nausea, breathing difficulty and nervous-system effects. NH_3 is released from nitrogenous organic waste; high concentrations irritate the eyes, throat and airway.

SO_2 and NO_2 react with atmospheric moisture to form acids that are deposited in rain. Sulfurous acid and nitric acid formation are written:



Studies in Nigeria have shown that dumpsites near homes, markets, schools and institutions add to pollution and health risk. Oko and Amaokpala, in Anambra State, are growing communities. Federal Polytechnic Oko and local commerce have increased daily waste, most of which is dumped in the open. Residents near these sites are exposed to odour, smoke and gases. Few measurements of ambient air around the dumpsites have been published. This study therefore measured NO_2 , H_2S , CO , NH_3 and SO_2 and compared the results with limits cited from WHO and USEPA.

2. Materials and methods

2.1 Aim and objectives

The aim was to assess ambient air quality at selected dumpsites in Oko and Amaokpala. The objectives were to measure the gaseous pollutants, compare the values with WHO and USEPA limits used in the study, evaluate environmental and health implications, and identify the main contributors to pollution at the sites.

2.2 Design and study area

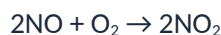
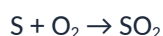
An experimental field survey was used. The sites are in Oko and Amaokpala, Orumba North Local Government Area, Anambra State, in the tropical rainforest zone, with rainy and dry seasons, moderate to high temperature and high humidity. Three dumpsites were chosen for proximity to housing, volume of waste and intensity of activity: the dumpsite along Federal Polytechnic Oko, Abattoir Eke Oko, and the Amaokpala dumpsite.

2.3 Equipment and sampling

A portable multi-gas analyser, gas sensors, a GPS unit, thermometer, field sheets, gloves, masks and a camera were used. At each site, six points were selected. The analyser was held about 1.5 m above ground, in the breathing zone, during daytime. It was allowed to stabilise before NO_2 , H_2S , CO , NH_3 and SO_2 were recorded in parts per million. Repeat readings were taken and the six points were averaged.

2.4 Principle of detection

The analyser uses electrochemical sensors. Target gases generate a current proportional to concentration. Combustion and atmospheric reactions relevant to the measured gases include:



2.5 Quality control and analysis

The analyser was calibrated before fieldwork. Measurements were taken under similar conditions, duplicate readings were recorded, and instruments were used to the manufacturer's instructions. Protective equipment was worn. Means were calculated as

$$\bar{X} = \Sigma x / n$$

where $\bar{X}$ is the mean concentration, Σx is the sum of observations and n is the number of observations. Results were compared with the limits in Table 1. The source table printed the WHO SO_2 value as -0.015 ppm; that leading minus is treated here as a typographical error, and 0.015 ppm is used. Later site tables also cite 0.145 ppm and 1.55 ppm for some WHO or USEPA comparisons. Those figures are retained as reported and are not the same as Table 1.

Table 1. Comparison limits cited for ambient gases (ppm)

Pollutant	WHO	USEPA	Period	Source year
NO ₂	0.106	0.100	1 hour	WHO 2021; USEPA 2022
H ₂ S	Not specified	Not specified	1 hour	—
CO	35	Not specified	1 hour	2021
NH ₃	Not specified	Not specified	—	—
SO ₂	0.015	0.075	1 hour	2021

3. Results

Air was measured at the three dumpsites. Point values, means and the limits written against each table are given below. Blank cells are limits that were not entered in the source tables.

Table 2. Federal Polytechnic Oko dumpsite (ppm)

Gas	1	2	3	4	5	6	Mean	USEPA	WHO	Remark
NO ₂	1.36	1.63	1.40	1.32	1.56	0.40	1.27	0.100	0.106	
H ₂ S	0.90	0.40	0.28	1.79	1.84	0.72	0.99			
CO	36.50	40.10	38.56	38.50	41.10	38.30	38.84		35.5	
NH ₃	9.61	12.11	13.12	15.11	12.13	11.12	12.20			
SO ₂	0.71	0.63	0.02	0.51	0.55	0.67	0.52	0.075	0.015	

This site receives hostel, restaurant, market and institutional waste and is frequently burned. Means were NO₂ 1.27 ppm, H₂S 0.99 ppm, CO 38.84 ppm, NH₃ 12.20 ppm and SO₂ 0.52 ppm. The narrative compared NO₂ and SO₂ with 0.155 ppm and 0.145 ppm and CO with 35.5 ppm; on those figures, and also against Table 1, NO₂, SO₂ and CO were above the cited limits.

Table 3. Abattoir Eke Oko dumpsite (ppm)

Gas	1	2	3	4	5	6	Mean	USEPA	WHO	Remark
NO ₂	2.80	1.85	2.31	0.97	1.80	2.54	2.05		1.55	Acid rain
H ₂ S	1.34	1.67	2.30	3.52	2.06	2.60	2.25			
CO	41.20	40.10	44.10	37.61	41.60	44.30	41.49		35.00	Acid rain
NH ₃	13.70	11.11	13.68	14.10	12.31	14.86	13.10			
SO ₂	0.80	1.66	2.41	1.12	2.31	1.32	1.60		0.145	Acid rain

The abattoir site, beside Eke Oko market, receives animal waste and municipal refuse. It had the highest means: NO₂ 2.05 ppm, H₂S 2.25 ppm, CO 41.49 ppm, NH₃ 13.10 ppm and SO₂ 1.60 ppm. The source table labelled the ammonia row HN₃; that is corrected here to NH₃. The remark “acid rain” was entered against NO₂, CO and SO₂.

Table 4. Amaokpala dumpsite (ppm)

Gas	1	2	3	4	5	6	Mean	USEPA	WHO	Remark
NO ₂	2.71	0.91	1.86	1.52	1.22	1.30	1.59		1.55	Acid rain
H ₂ S	1.61	0.91	0.86	0.70	1.10	1.20	1.06			
CO	34.70	37.30	36.70	40.10	40.61	41.10	38.42		35.5	Acid rain
NH ₃	8.20	8.60	10.50	7.44	7.30	11.60	8.94			
SO ₂	0.50	0.60	0.20	0.46	1.63	1.31	0.78		0.145	Acid rain

Amaokpala serves housing, a student hostel and shops. Means were NO₂ 1.59 ppm, H₂S 1.06 ppm, CO 38.42 ppm, NH₃ 8.94 ppm and SO₂ 0.78 ppm, lower than Abattoir Eke Oko but still above several of the limits cited in the table.

4. Discussion

All three sites showed elevated CO, NO₂ and SO₂. Abattoir Eke Oko was the most polluted, consistent with animal remains, municipal waste and open burning. High NO₂ and SO₂ favour acid deposition. CO can impair oxygen transport. Prolonged H₂S exposure may irritate the eyes and airway. The source discussion places the Polytechnic NO₂ and SO₂ means above 0.155 ppm and 0.145 ppm, while Table 1 cites 0.106 ppm and 0.015 ppm. Either set of

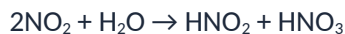
limits is exceeded by the measured means. The 1.55 ppm figure entered as a WHO or USEPA value in Tables 3 and 4 is much higher than the 1-hour NO₂ values in Table 1 and should not be treated as a regulatory limit without a source.

4.1 Reactions of the measured gases with water

Atmospheric water occurs as vapour, cloud droplets, fog, dew and rain. The five gases interact with that water as follows.

4.1.1 Nitrogen dioxide

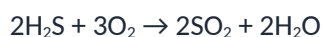
NO₂ reacts with moisture to form nitrous and nitric acids:



Nitric acid in rain lowers the pH of soil and water, damages leaves, corrodes metal and concrete, and irritates the airway. Acidification can kill fish and other aquatic organisms.

4.1.2 Hydrogen sulfide

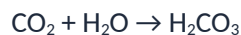
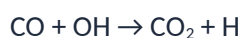
H₂S dissolves to hydrosulfuric acid and can be oxidised to SO₂:



The products add acidity and odour. H₂S itself causes headache, dizziness, eye irritation and breathing difficulty, and its oxidation feeds sulfuric acid formation.

4.1.3 Carbon monoxide

CO does not react readily with water under ordinary conditions. Atmospheric oxidation by the hydroxyl radical is written:



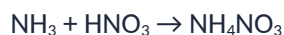
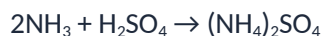
The CO₂ contributes to the greenhouse effect and to weak carbonic acid in rain. The health effect of CO remains binding to haemoglobin. CO also takes part in reactions that form ozone and smog.

4.1.4 Ammonia

NH₃ dissolves to ammonium hydroxide, which partly ionises:



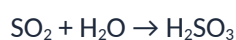
This raises alkalinity. NH₃ also forms secondary particles:



Ammonium salts add to PM_{2.5}. Deposited ammonium can drive eutrophication. High NH₃ irritates the eyes, nose, throat and lungs.

4.1.5 Sulfur dioxide

SO₂ dissolves to sulfurous acid, which oxidises to sulfuric acid. Direct oxidation to SO₃ is also written:



Sulfuric acid is a principal component of acid rain. It acidifies soil and lakes, corrodes roofs, pipelines and buildings, and irritates the lung.

Taken together, the dumpsite gases can contribute to acid rain, reduced visibility, corrosion, soil and water degradation, and respiratory and cardiovascular illness in Oko and Amaokpala. The measured concentrations identify the three dumpsites as local sources. The reactions above are standard atmospheric pathways; they were not measured directly in this field survey.

5. Conclusion

Ambient air at the three dumpsites contained elevated NO_2 , CO and SO_2 relative to the limits cited in the study. Abattoir Eke Oko was the most polluted site. Open dumping and open burning, close to housing, a market and Federal Polytechnic Oko, are the plausible causes. The results support sanitary disposal, a ban on open burning and continued monitoring.

6. Recommendations

The following actions follow from the measurements.

1. Replace open dumps with engineered sanitary landfills, with liners, leachate control and gas management, in Oko, Amaokpala and neighbouring communities.
2. Prohibit open burning and enforce the ban. Composting and controlled treatment with pollution controls are safer alternatives.
3. Monitor NO_2 , SO_2 , CO, H_2S , NH_3 and particulate matter ($\text{PM}_{2.5}$ and PM_{10}) around dumpsites, markets, schools and housing, and publish the results.
4. Run public campaigns, including in local languages and schools, on the health effects of open dumping and burning.
5. Separate organic waste, plastics, paper, glass, metals and hazardous waste at source, and support recycling.
6. Site future disposal facilities away from homes, schools, hospitals and markets, with vegetated buffer zones. Relocate or upgrade sites that are already too close.
7. Strengthen inspection and penalties under existing sanitation and waste regulations.
8. Involve communities in collection, sanitation committees and clean-up programmes.
9. Extend the work to soil, groundwater, heavy metals, particulate exposure and health outcomes in nearby residents.

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