



Emission from Uyo Main Refuse Dumpsite and Potential Impact on Health

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Authors' contributions

This work was carried out in collaboration among all authors. This work was part of author SAN thesis work. Author MJA was a major supervisor. Authors AHI and RNO were co-supervisors. Author SAN did the study design, wrote the protocol, statistical analysis, literature searches, analyses of study, supervisors read and approved the final manuscript. All authors read and approved the final manuscript.

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ABSTRACT

This paper presents potential impact on health of emission from landfill site on Uyo village road, Uyo local government area of Akwa Ibom State, Nigeria. Three sampling points were assessed for particulate matter (PM_{2.5} and PM₁₀), nitrogen dioxide (NO₂), sulphur dioxide (SO₂), carbon monoxide (CO), hydrogen sulphide H₂S, ammonia (NH₃), total volatile organic carbon (TVOC) and hydrogen cyanide (HCN) using highly sensitive digital portable meters. The data obtained were expressed in terms of an air quality index. Air quality index indicates that the ambient air can be described as unhealthy for sensitive groups for NO₂, unhealthy for SO₂ and PM_{2.5} and moderate for CO, respectively. H₂S, NH₃, TVOC, HCN, PM₁₀ were not indicated in USEPA air quality standards. It recommended that stringent and proper landfill emissions management together with appropriate burning of wastes should be considered in the study area to ease the risks associated with these pollutants on public health.

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1. INTRODUCTION

Air quality report on dumped municipal solid waste around Nigerian cities has indicated that values exceeded their threshold limits relative to the United States Environmental Protection Agency. This may be due to noxious management of municipal solid waste together with unrestrained open air *in situ* burning of waste, whose direct consequences on biodiversity and greenhouse effect cannot be overstressed. [1], attributed mortalities to air pollution and the synergistic role they play in the development of respiratory diseases. Also, World Health Organization has acknowledged air pollution as an elementary health threat [2]. The generation and poor management of municipal solid wastes in Nigerian cities come with unfavorable associated environmental and health consequence. Air Pollution associated with dumped municipal solid waste has become a major source of concern due to odour released and the emission of greenhouse gases like: sulphur, oxide of nitrogen and carbon monoxide as well as release of suspended particulate matter through *in situ* burning.

Additionally, literature report indicated that insufficiencies in effective waste supervision of most developing nations had detrimental effect on human health and biodiversity with corresponding unfavorable consequences on keystone resources [3]. The major route of exposure to air pollution is by the process of inhalation [4]. Nevertheless, air pollution can also cause eyes and airway irritation, nasal, anoxia, wheezing, coughing, and even lung and heart issues, which escalate risk to asthma and heart problem. However, in extreme cases it can result to mortality. The chronic exposure to air pollution can compromise the immune system and cause systemic cancer of the nervous, reproductive and respiratory systems.

Moreover, noxious emission emitted during burning of waste, suspended particulates matter release contains anthropogenic substance which can irritate the nasal cavity or the lungs, carcinogenic, and cause poisons ranging from cold to other air-borne diseases [5]. Also, people whose residence are adjacent to dumpsite are predispose to cardiovascular diseases [6,1], like lung asthma, cancer, bronchitis, birth defect, and premature mortalities [7]. In another report on the relative aerobic microbial circulation of a dumpsite around Nigerian cities indicated 15%

Serratia spp, 19% *Klebsiella* spp, 37% *Escherichia coli*, 13% *Pseudomonas* spp, 8% of *Staphylococcus* spp, 7% of *Enterococcus* spp, with the slightest being 1% of *Salmonella* spp. [8].

Uyo main refuse dumpsite in Uyo local government area is the site that was engulfed by major gully erosion many years ago, and was adopted by the Akwa Ibom State government as erosion control measures to reclaim the site. Today air quality around Uyo village road main refuse dumpsite is affected by foul odours which is of interest to public health. Several health related issues have been reported by the residence living around the municipal solid waste dump site. In the present study, in view of the gravity of the situation, air quality index proposed by USEPA was used to assess the health risk for the purpose of determining the contamination level of emissions from landfill site and planning a management strategy accordingly.

2. MATERIALS AND METHODS

2.1 Study Area

Uyo village road is located in Uyo local government area. Uyo is the capital city of Akwa Ibom State, Nigeria. It's situated at 5.03° North latitude, 7.93° East longitude and 196 meters elevation above the sea level. The average annual temperature in Uyo is 26.4°C. The rainfall here averages 2509 mm.

2.2 Data Collection

2.2.1 Sampling

Concentrations of air pollutants were measured at three (3) sampling points at the dumpsite. Highly sensitive digital portable meters were used for the measurement of NO₂, SO₂, H₂S, HCN, NH₃, VOC, CO and SPM detailing their alarm levels (Table 1).

Table 2 shows the air quality index for priority pollutant. While Table 3 present air quality index levels and associated health impacts with their colour code. Air quality index is a ranking set by USEPA for evaluating health effects that can happen within a few hours or days after breathing polluted air. The air quality index for priority pollutant are categories ranging from good to hazardous. In the absent of air quality

Table 1. Gaseous emissions and noise measuring instruments

Parameter	Equipment	Alarm levels
SO ₂	SO ₂ Crowcon Gasman S/N: 19648H	2.0 ppm
NO ₂	NO ₂ Crowcon Gasman S/N: 19831N	3.0 ppm
H ₂ S	H ₂ S Crowcon Gasman S/N: 19502H	10 ppm
CO	CO Crowcon Gasman S/N: 19252H	50 ppm
NH ₃	NH ₃ Crowcon Gasman S/N: 19730H	25 ppm
HCN	HCN Crowcon Gasman S/N: 19773H	5 ppm
SPM	Haz-Dust TM 10 µg/m ³ particulate monitor	+1-0.0210 µg/m ³

Table 2. Air quality index for priority pollutant

Category	QAI	PM _{2.5}	CO	SO ₂	NO ₂
		(µg/m ³) 24-hour	(ppm) 8-hour	(ppm) 1-hour	(ppm) 1-hour
Good	0 - 50	0.0 – 12.0	0.0 – 4.4	0 - 0.035	0 – 0.053
Moderate	51 – 100	12.1 – 35.4	4.5 – 9.4	0.036 – 0.075	0.054 – 0.100
Unhealthy for Sensitive Groups	101– 150	35.5 – 55.4	9.5 - 12.4	0.076 – 0.185	0.101 – 0.360
Unhealthy	151 – 200	55.5 – 150.4	12.5 - 15.4	0.186 – 0.304	0.361 – 0.649
Very Unhealthy	201 – 300	150.5– 250.4	15.5 - 30.4	0.305 – 0.604	0.605 – 1.249
Hazardous	301 - 500	250.5– 500.4	30.5 – 100.4	0.605 – 1.004	1.250 – 2.049

Source: USEPA 2016

Table 3. Air quality index level and associated health impacts

AQI level of health concern	Meaning	Colour code
Good	Air quality is considered satisfactory, and air pollutant poses little or no risk	Green
Moderate	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.	Yellow
Unhealthy for Sensitive Groups	Members of sensitive groups may experience health effects. The general public is not likely to be affected.	Orange
Unhealthy	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.	Red
Very Unhealthy	Health warnings of emergency conditions. The entire population is more likely to be affected.	Purple
Hazardous	Health alert: everyone may experience more serious health effects.	Maroon

Source: USEPA 2016

standards for landfill emissions on health, the results obtained in these studies were compared with the USEPA ambient air quality standards (air quality index).

3. RESULTS AND DISCUSSION

Table 4 presents results of landfill air quality measurements in the study area compared with the USEPA ambient air quality standards (air quality index).

NO₂ were in the range of 0.2 – 0.3 ppm which was above the permissible limit of USEPA

ambient air quality standards. In terms of air quality index rating the air quality for NO₂ at the three-sampling point SP1 to SP3 was unhealthy for sensitive groups. This means that members of sensitive groups around the dump site may experience health effects.

NO₂ is associated with unfavorable consequences on human health. [9] reported that, at high concentrations, nitrogen dioxide (NO₂) acts as an irritant of the airways and exposure can yield inflammation and bronchoconstriction (narrowing of the lungs) and

can influence the immune cells in the lungs, increasing vulnerability to respiratory infections. Asthmatics individuals are most vulnerable, although levels of NO₂ may also produce effects on the lung function of non-asthmatics individuals. As a result, emissions of NO₂ from active well-managed landfill sites should not significantly impact local air quality and consequently the health of those living near the landfill site. Proper control of emissions and strict regulation of landfill sites should ensure that emissions do not result in an exceedance of ambient Air Quality Objectives as set in [10] air quality strategy.

The concentration of SO₂ was found in the range of 0.1 – 0.2 ppm which was above the permissible limit of USEPA ambient air quality standards. In terms of air quality index rating the air quality for SO₂ at the three-sampling point SP1 – SP3 was unhealthy. This implies that everyone around the dumpsite may begin to experience health effects. Members of sensitive groups may experience more serious health effects. SO₂ can affect the respiratory system and the functions of the lungs, and causes irritation of the eyes. Inflammation of the respiratory tract causes coughing, mucus secretion, aggravation of asthma and chronic bronchitis and makes people more prone to infections of the respiratory tract. Hospital admissions for cardiac disease and mortality increase on days with higher SO₂ levels. When SO₂ combines with water, it forms sulfuric acid; this is the main component of acid rain which is a cause of deforestation. Regulation of landfill sites and pollution control measures should limit SO₂ emissions. Nevertheless, provided the site is appropriately managed and regulated, it is unlikely that emissions from landfill sites will significantly affect local air quality.

The results of carbon monoxide (CO) were in the range of 4.0 – 7.0 ppm which was above the permissible limit of USEPA ambient air quality standard. In terms of air quality index rating the air quality for CO at the three-sampling point SP1

– SP3 was moderate. This means that air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution around the dumpsite. Carbon monoxide enters the bloodstream through the lungs and binds chemically to hemoglobin, the substance in blood that carries oxygen to cells. In this way, carbon monoxide reduces the amount of oxygen reaching the body's organs and tissues. People with cardiovascular disease, such as angina, are most at risk from carbon monoxide. These individuals around the dumpsite may experience chest pain and more cardiovascular symptoms if they are exposed to carbon monoxide, particularly while exercising.

The concentration of hydrogen sulphide (H₂S) was found in the ranged of 0.1 – 0.2 ppm but was not indicated in the permissible limit of USEPA ambient air quality standards. H₂S is produced in landfill sites when high sulphate bearing materials like gypsum and plasterboard are mixed with biodegradable waste. The composition of the waste material and the design and management of the site will determine the amount of H₂S produced and concentration in landfill gas can vary considerably.

At low concentration, hydrogen sulphide may cause irritation to the mucous membranes of the eye and respiratory tract. Exposure to high concentrations results in depression of the central nervous system, loss of consciousness and respiratory paralysis [11].

The concentration of NH₃ was found in the ranged of 2.0 – 4.0 ppm but was not indicated in the permissible limit of USEPA ambient air quality standards. Ammonia can lead to damage of terrestrial and aquatic ecosystems through deposition of eutrophying pollutants and through acidifying pollutants. Precursor to secondary PM and therefore contributes to the ill-health effects caused by PM₁₀ and PM_{2.5}.

Table 4. Landfill air quality measurements

Sampling Points	NO ₂ ppm	SO ₂ ppm	H ₂ S ppm	CO ppm	NH ₃ ppm	CH ₃ O ₃ (ppm)	TVOC mg/m ³	HCN ppm	PM _{2.5} µg/m ³	PM ₁₀ µg/m ³
SP ₁	0.3	0.1	0.2	5.0	4.0	0.521	2.341	<0.1	49	84
SP ₂	0.2	0.2	0.1	7.0	2.0	0.555	0.456	<0.1	52	86
SP ₃	0.3	0.2	0.2	4.0	3.0	0.601	0.625	<0.1	63	92
Mean	1.77	0.17	0.17	5.33	3.0	0.92	1.14	<0.1	75.7	87.3

The concentration of the PM_{2.5} μm particulate matter ranged from 49 - 63 $\mu\text{g}/\text{m}^3$ which were above the permissible limit of USEPA ambient air quality standard. In terms of air quality index rating the air quality for PM_{2.5} at the three sampling point SP1 – SP3 was unhealthy. This means that everyone around the dumpsite may begin to experience some unfavorable health effects, and members of the sensitive groups may experience more serious effects. The concentration of PM₁₀ particulate matter ranged 84 – 92 $\mu\text{g}/\text{m}^3$ but was not indicated in the permissible limit of USEPA ambient air quality standards.

Both fine and coarse particles can accumulate in the respiratory system and are associated with numerous health consequences. Coarse particles can aggravate respiratory conditions such as asthma. Exposure to fine particles is associated with a number of serious health effects, including premature death. Unfavorable health consequences have been associated with exposures to PM over both short periods such as a day and longer periods such as a year or more.

When exposed to PM, people with existing heart or lung diseases such as asthma, chronic obstructive pulmonary disease, congestive heart disease, or ischemic heart disease are at increased risk of premature death or admission to hospitals or emergency rooms. The elderly also is sensitive to PM exposure. They are at increased risk of admission to hospitals or emergency rooms and premature death from heart or lung diseases. When exposed to PM, children and people with existing lung disease may not be able to breathe as deeply or vigorously as they normally would, and they may experience symptoms such as coughing and shortness of breath. PM can increase susceptibility to respiratory infections and can aggravate existing respiratory diseases, such as asthma and chronic bronchitis, causing more use of medication and more doctor visits.

The concentration of total volatile organic (TVO) compounds was found in the ranged of 0.456 – 2.341 mg/m^3 but was not indicated in the permissible limit of USEPA ambient air quality standards. Respiratory, allergic, or immune effects in infants or children are associated with man-made volatile organic compounds and other indoor or outdoor air pollutants [12]. Key signs or symptoms associated with exposure to VOCs

include conjunctival irritation, nose and throat discomfort, headache, allergic skin reaction, dyspnea, declines in serum cholinesterase levels, nausea, vomiting, nose bleeding, fatigue, dizziness.

The concentration of hydrogen cyanide was found in the ranged of $< 0.1 \text{ mg}/\text{m}^3$ but was not indicated in the permissible limit of USEPA ambient air quality standards. Inhalation hydrogen cyanide exposure include; mild to moderate and severe effects. Mild to moderate consequences include headache, confusion, anxiety, dizziness, weakness and loss of consciousness. Severe effects include coma, seizures, and dilated pupils (mydriasis) [13].

4. CONCLUSION

The findings of this study in general revealed that high risks are associated with public health near the dumping sites. Air quality index indicates that the ambient air can be described as unhealthy for sensitive groups for NO₂, unhealthy for SO₂ and PM_{2.5}, and moderate for CO, respectively. H₂S, NH₃, TVOC, HCN, PM₁₀ were not indicated in USEPA air quality standards. The results recommend that stringent and proper landfill emissions management together with close burning management of wastes should be considered in the study area to ease the risks associated with these pollutants on public health. Further monitoring of the dump site is recommended as well as research by biomedical expert to make public the rigorous unfavorable consequences that landfill emissions might induce in humans, particularly individuals in vulnerable populations.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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