AIR QUALITY ASSESSMENT OF SOME SELECTED UNCONTROLLED DUMPSITE IN WARRI METROPOLITAN CITY

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Abstract: The air quialty of six selected uncontrolled dumpsite monitored revealed the impact of municipal solid waste on the air quality of Warri municipal area. The study covers three months (August – October 2019) at Opete, Okuvo, NPA, Cemetery Road, Refinery Road and Osubi. The Aeroqual 500 series was used to investigate the parameters such as SPM, H_2S, NOx, CO, SOx, O_3 and CxHy/VOCs. The comparison of the emitted gases results in the following order, SPM > NOx > SOx > H_2S > O_3 > CxHy/VOCs > CO. Moreover, Opete has the highest average emissions of most gasses such as CO, H_2S, NOx, and O_3 (31.42%, 43.81%, 18.86% and 17.66%), while SPM and SOx were the major emissions from Okuvo dumpsite. The NPA dumpsite has a characteristic high emission percentage of CxHy/VOCs because of its proximity to several jetties and other hydrocarbon sources. This study results show a possibility of bioaccumulation of these toxic gases through the inhalation exposure pathway in human staying at residents, scavengers and commercial shops close to the dumpsites over a long period. The long-time exposure to the percentage of gases emitted in this study could cause lung damage and respiratory problems but vary from one pollutant to another. The Air Quality Index (AQI) calculated indicates pollution at all the dumpsites, which is a cause of acute health impacts to the habitants.

Keywords: Air quality, Gases, Dumpsite, Pollution, Waste.

I. INTRODUCTION

Environmental uncleanness, pollution, and contamination resulting from solid waste management are a universal issue that requires urgent investigation and solution [1]. This urgent attention is necessary to address the current wave of pollution for economic sustainability [2], [3]. Much attention should be directed to emerging and developing nations on issues regarding waste management since there is uncoordinated day to day activities capable of prompting, encouraging and stimulating unsustainable management of waste [4]. Developing facilities for managing waste is a function of the environment under consideration, and the nature of waste in such vicinity, be it in the rural settings or urban arrangement [1]. Irrespective of the arrangement as mentioned earlier, negative operational precincts, political, technical and economic legislations suffered in diverse operation systems [5]. Developing and emerging countries suffer constant, continuous and uncontrolled waste disposal due to human activities that generate serious pollution, which affects the terrestrial and aquatic domain [6].

Unfortunately, humans living in such environment carry out open burning of waste which in most cases result into carbon monoxide, carbon dioxide, sulphur II oxide, Nitrogen II oxide and other emissions that is highly inimical to health and the atmosphere [7]. One other noticeable or observable fact in the developing countries is a case of scavengers who go about picking items around common dump sites, and this is a widespread activity which is hazardous and could lead to health risk in the lives of people who indulge in such risky undertakings [8]. Another popular and noticeable activities in developing countries has to do with dumbing of waste along water bodies or ocean, this could lead to environmental contamination and sickness in the lives of people who drink water from such systems [9].

The air quality has impacted human health and welfare worldwide and it continues to call for great attention. Air quality correlation with specific disease such as, shortness of breath, sore throat, chest pain, nausea, asthma, bronchitis and lung cancer has been widely studied over the years ([10], [11], [12], [13]. Other severe effects of air pollution include high blood pressure and cardiovascular problems [10],[11]. Also reported by Laden *et al.*, [14] is the Correlations between air quality and increased morbidity and mortality rates. In addition, air pollution do have effect on animals, forests and vegetation, and aquatic ecosystems.

The Warri Metropolitan City is part of the south-south geopolitical zone of Nigeria, and it has the main dumping sites that the Municipality of Warri and Environ uses. These sites are in operation for quite some time ago as an uncontrolled open dump with constant open fires emitting different contaminants in the environment. The past work has associated the toxic gases emission from the dumpsite with health impact [15]. Therefore, this study will examine the air quality from the selected dumpsite to ascertain the possible release of poisonous pollutant into the atmosphere.

II. MATERIALS AND METHODS

A. Site description

Delta is located in the Niger Delta of Nigeria, with Warri as one major oil city. Warri houses Refinery and Petrochemical Company (WRPC), Nigerian Gas Company (NGC), other indigenous oil companies and oil service companies. Warri metropolis is the most populous metropolis in Delta, with a population of about 8000,000 [16].

The high population of the metropolis results in an increased generation of waste, causing litters of the uncontrolled dumpsite. The usual type of waste at the dumpsites are organic, nonorganic, hazardous and non-hazardous. These wastes originated from domestic, commercial, agricultural, industrial and electronic wastes.

Due to the increasing number of uncontrolled dumpsite within the metropolis and the high rate of waste generation, the need for the current study to consider the impact of the dumpsites on the air quality of the municipality. The study selected six (6) uncontrolled dumpsites in Warri Metropolitan City to monitor the air quality for three months (August 2019 to October 2019).

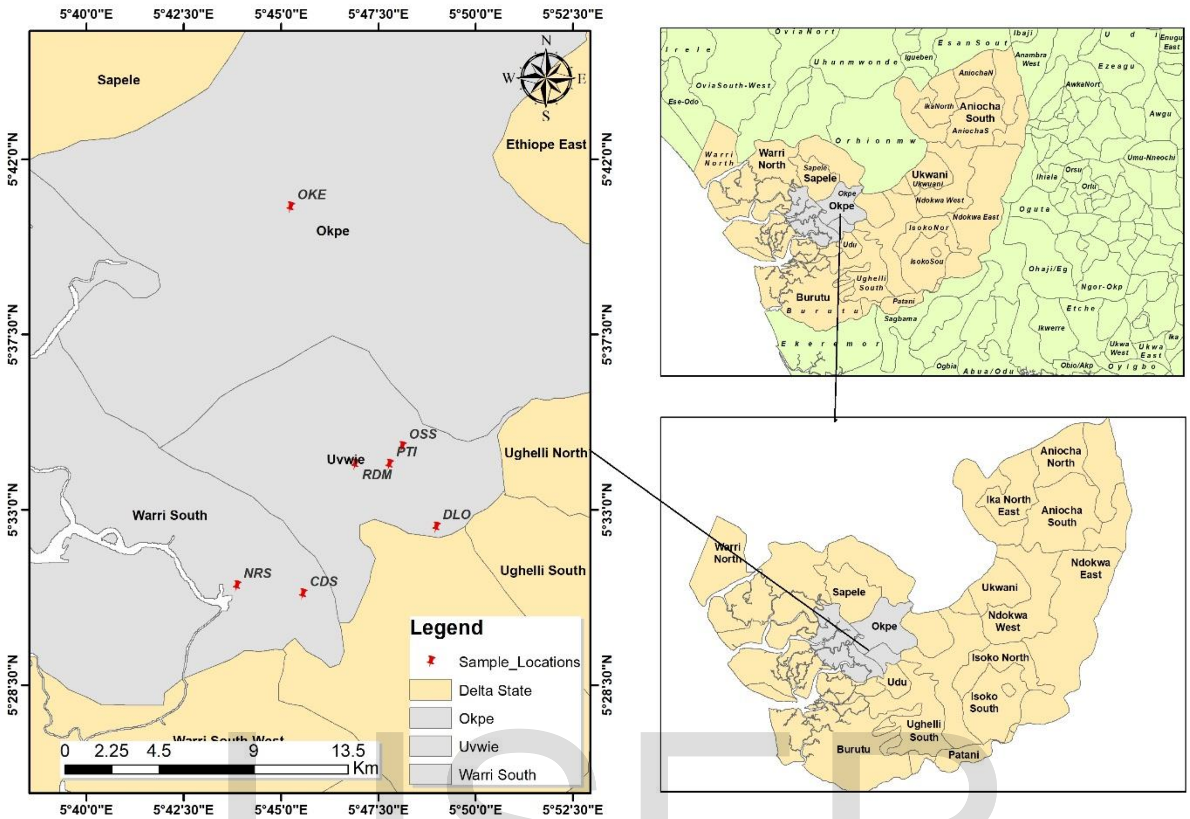

Fig. 1: Map of the selected uncontrolled dumpsites

B. **Sampling and Analysis**

At the selected dumpsite, Seven (7) air quality monitoring parameters, SPM, H_2S, NOx, CO, SOx, O_3 and CxHy/VOCs, were determined using Aeroqual, 500 series. The Instrument has 30 different compatible gas sensors with the display screen. The atmospheric conditions of the selected dumpsites were put into consideration when measurement were taken. The direction of wind and speed of the wind influences the position of the sensor at three different points and a height of two meters above the study site to obtain an optimum reading of the gas emission device.

C. AIR QUALITY INDEX (AQI)

The transformation of individual air pollutant values into a single number is defined as Air Quality Index. As suggested by Kaushik et al. [17], AQI was estimated using the concentration of each pollutant in the equation:

$$Q = 100\, V/VS$$

Q = quality rating, V = observed value of pollutant and Vs = the National Ambient Air Quality Standards [19], [20].

If total 'n' = no of pollutants monitoring, therefore, the calculated formula for the geometric mean of 'n' number of quality ratings are shown below.

$$g = Anti\ log\{(loga + logb + logc + \cdots . + logx/n)\}$$

G = geometric mean, while a, b, c, and x represent different pollutant values of quality rating, and n = number of values of quality rating.

III. RESULTS AND DISCUSSION

The results showed the measured concentrations of SPM, H2S, NOx, CO, SOx, O3 and VOC in the selected dumpsites in August 2019, September, 2019 and October 2019 are presented in Table 1. The levels of suspended particulates matter (SPM) in the study areas ranged between 490 and 985 µg/m3, showing that the particulates present in the atmosphere were higher than the regulatory limit of 40 µg/m3 [22]. High values of SPM may be attributed to colossal smoke billowing from the sites, as similarly reported by FEMA, [21].

Carbon monoxide (CO) is a toxic gas combined with haemoglobin to produce carboxyhaemoglobin, which replaces the space in haemoglobin that usually carries oxygen,

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but is ineffective for delivering oxygen to bodily tissues. The CO in the study areas ranges from 5.12 µg/m3 to 18.0 µg/m3, lower than the FEPA limit [22].

Also the concentration of sulphur dioxide in the atmosphere can affect the suitability of the habitat in plant communities and animal life. Emissions of Sulphur dioxide are a precursor to acid rain and atmospheric particulates. The levels of SO_2 in the study area ranged between 190 µg/m3 and 247 µg/m3, which is below regulatory limits of 100 ppm [22].

Hydrogen sulphide (H2S) concentrations in the study ranged from 162 µg/m3 to 264 µg/m3, higher than the WHO limit [18]. The explosive limits of 4% - 44% pose an explosion hazard within the dumpsites. According to information collected by the Connecticut Department of Health, the concentration of hydrogen sulphide in ambient air around a landfill is usually close to 15 ppb.

The level of NOx in the air within the selected dumpsite ranged between 145 µg/m3 - 240 µg/m^3, which is far higher than the WHO limit of 40 µg/m3.

Ozone in the air within the dumpsites ranged between 41 µg/m3and 45.8 µg/m^3 , which is lower than the WHO limit [18] of 100 µg/m3.

This study has shown that the VOC levels in ambient air at the selected dumpsites is lower than the regulatory limit of 100 µg/m3 of the WHO[18]. VOC levels range from 15.5 µg/m3 to 29.4 µg/m3 within the dumpsites.

Table 1. Measured Concentrations (μg/m^3) of Air Parameters and VOCs Across Various Dumpsites

	Cemetery Road	NPA	Opete	Refinery Road	Osubi	Okuvo
August 2019						
SPM	490.00	610.00	860.00	780.00	755.00	950.00
CO	5.12	8.00	15.00	6.21	8.60	6.80
H_2S	170.00	156.00	260.00	0.00	0.00	0.00
NOx	218.00	235.00	240.00	230.00	231.00	145.00
Sox	0.00	0.00	0.00	190.00	220.00	245.00
CxHy/VOC	21.60	28.00	25.00	23.00	26.00	14.00
O_3	41.00	42.00	45.67	42.89	44.00	43.12
September 2019						
SPM	510.00	635.00	875.00	795.00	775.00	985.00
CO	5.34	8.00	17.00	5.90	9.50	7.40
H_2S	175.00	162.00	264.00	0.00	0.00	0.00
NOx	220.00	230.00	240.00	224.00	223.00	148.00
Sox	0.00	0.00	0.00	194.00	225.00	245.00
CxHy/VOC	22.90	28.60	27.00	24.50	28.00	16.00
O_3	41.50	42.46	45.88	43.12	44.21	43.00
October 2019						
SPM	550.00	680.00	910.00	810.00	800.00	985.00
CO	5.89	9.00	18.00	5.99	9.50	7.90
H_2S	182.00	171.00	268.00	0.00	0.00	0.00
NOx	220.00	230.00	254.00	230.00	220.00	153.00
Sox	0.00	0.00	0.00	196.00	228.00	247.00
CxHy/VOC	24.50	29.40	28.00	26.00	28.00	15.50
O_3	41.21	42.46	45.88	43.21	43.42	43.00

Table 2. Comparison of in-site Average Level (μg/m^3) in Ambient Air Sampled in dumpsites against WHO / FEPA Air Quality Regulatory Limit

Compounds	**Cemetery Road**	**NPA**	**Opete**	**Refinery Road**	**Osubi**	**Okuvo**	**Air quality regulatory limit (WHO/FEPA)** [18], [22]
SPM	516.67	641.67	881.67	795.00	776.67	973.33	40
CO	5.45	8.33	16.67	6.03	9.20	7.37	10ppm
H_2S	175.67	163.00	264.00	0.00	0.00	0.00	2
NOx	219.33	231.67	244.67	228.00	224.67	148.67	40
Sox	0.00	0.00	0.00	193.33	224.33	245.67	100ppm
CxHy/VOC	23.00	28.67	26.67	24.50	27.33	15.17	100
O_3	41.24	42.31	45.81	43.07	43.88	43.04	100

STATISTICAL ANALYSIS

In table1, the data reported was subjected to factor analysis such as Principal Component Analysis (PCA). Three (3) subsets were extracted from the original dataset, which composed of 7 datasets of measured concentrations of VOC and other harmful gases in August 2019. In September and October 2019, two (2) subsets were extracted after being subjected to the factor analysis. These parameters were analyzed using factor analysis by grouping the measured concentrations of 8 compounds into components based on a correlation matrix structure. These factors were subjected to Varimax Rotation with Kaiser Normalization.

In August 2019, PC1 and PC2 accounted for a more considerable variance of the data (49.23% and 34.53% for PC1 and PC2, respectively). Figs. 2(a) and 2(b) shows 83.76% of the data variance was associated with 2 PCs; distinct distributions of the loading values among the various parameters suggest different influences in monitoring the data. Fig 2(a) shows the result of PC1 in August 2019, accounting for 49.23% of the total data variance. The parameters with loading values greater than 0.5 comprised SPM, CO, and O_3, meaning there is a strong correlation of these parameters across these dumpsites with their composition in the atmosphere. PC2 accounts for 34.53% of the total data variance showed H2S and SOx had the highest loading values, suggesting the strong correlation of H_2S and SOx across the dumpsites in August 2019. Fig 3(a) further illustrates the ratios of the different sources contributing to the emission of these gases to the atmosphere in August 2019. The dumpsite in Opete had the highest contribution ratio for most gases like H_2S, CO, NOx and O_3 (44.3%, 30.16%, 18.48% and 17.66%). The dumpsite at Okuvo had the highest contribution of SPM and Sox (21.37% and 37.4%) in the atmosphere, while the dumpsite at NPA contributed the most to the emission of CxHy/VOCs (20.35%).

In September 2019, PC1 had the most significant variance accounting for 50.63% of the total data variance showing a strong correlation in 5 of the gases like SPM, H_2S, NOx, SOx and CxHy/VOCs (Fig. 2d). Fig 3(b) shows that Okuvo contributed the most to the emission of SPM and Sox (21.53% and 36.90%), NPA contributed to the highest emission of CxHy/VOCs (19.46%), and Opete had the highest emission of CO, H_2S, NOx and O_3 (31.99%, 43.93%, 18.68% and 17.63%).

In October 2019, the most significant variance was 51.95% and PC1 has the highest contributoin and a strong correlation for five gases such as SPM, H_2S, NOx, Sox and CxHy/VOCs (Fig. 2f). Okuvo (Fig. 3(c)) had the highest contribution ratio to the emission of SPM and Sox (20.8% and 36.81%), while Opete had the highest contribution rates of 4 of the gases as follows, CO, H_2S, NOx, and O_3 (31.98%, 43.93%, 18.68% and 17.7%). The NPA site had the highest contribution ratio for CxHy/VOCs (19.42%).

Fig 3(d) shows the average contribution ratios of the various sources of emission over the three months studied, with Opete having the highest average emissions of the majority of the gases, including; CO, H_2S, NOx and O_3 (31.42%, 43.81%, 18.86% and 17.66%), Okuvo contributing to the highest emission of SPM and Sox (21.23% and 19.72%) and NPA having the highest contribution ratio of CxHy/VOCs

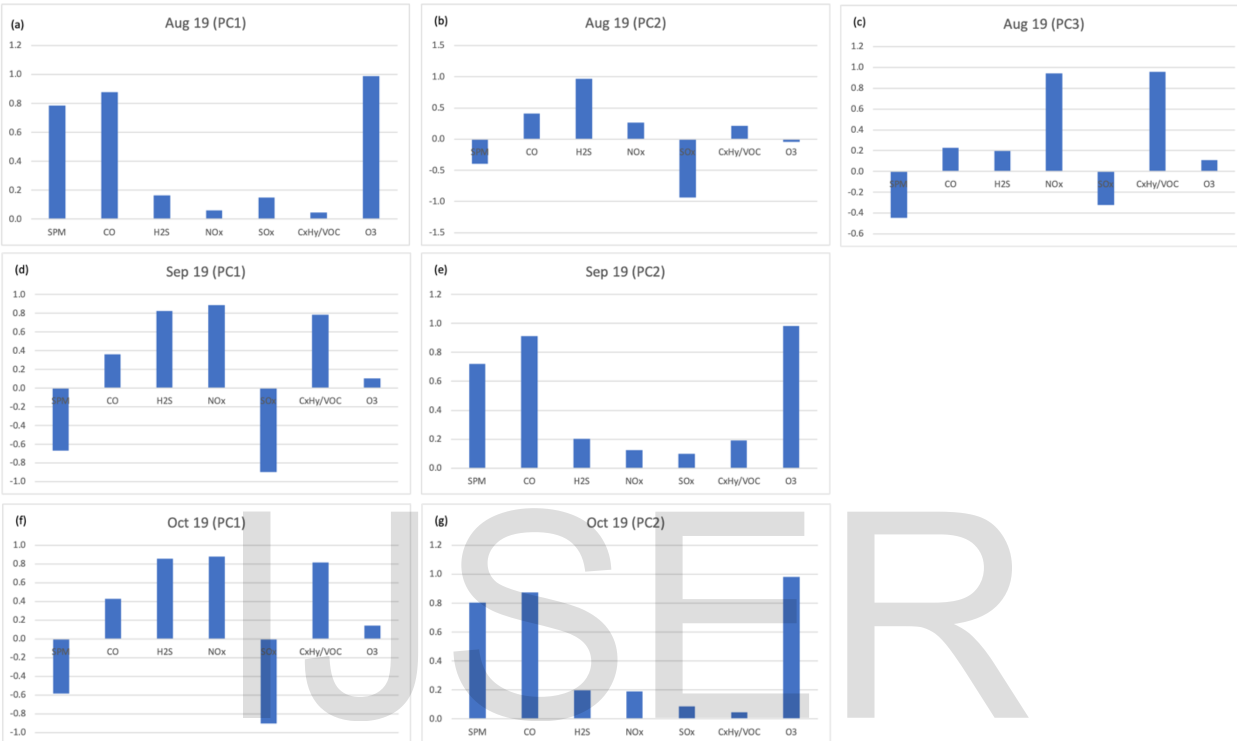

Fig 2. Loading values of parameters across their various principal components for the three months.

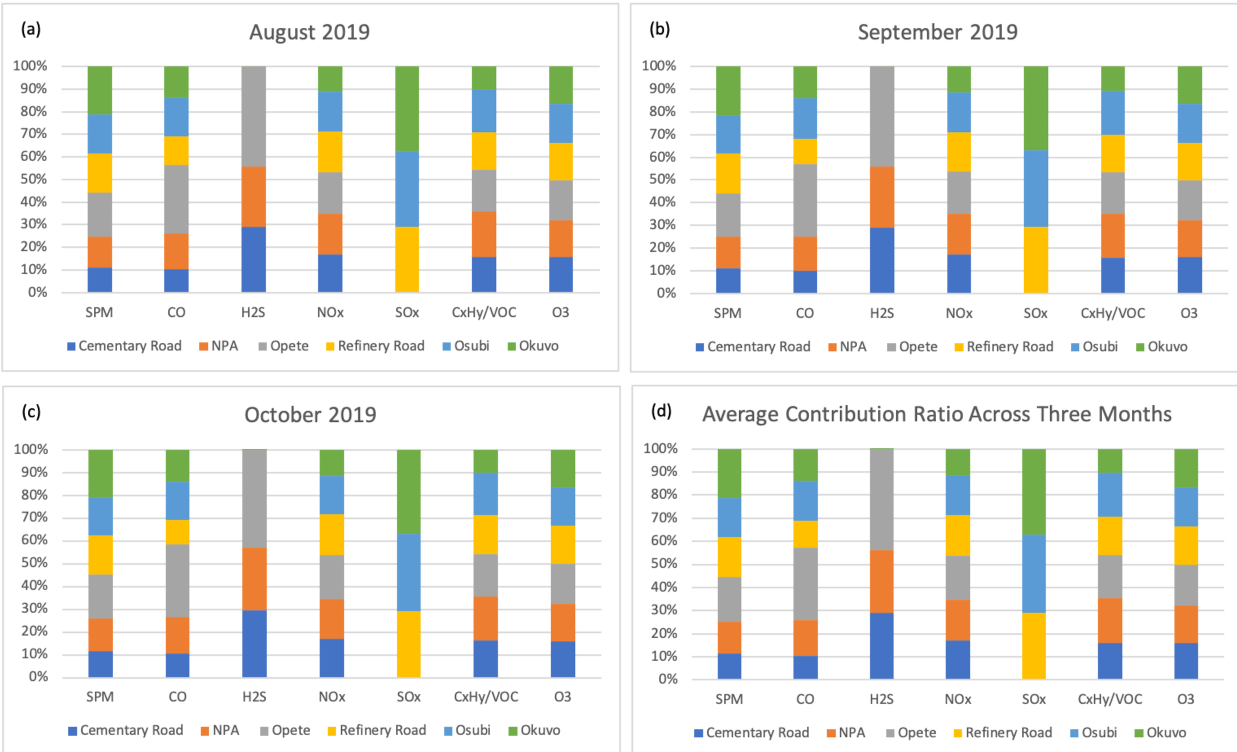

Fig 3. Contribution ratios of the selected dumpsites in Warri metropolitan city

Table 3 shows the results of PCA and the total variances calculated in this study. The total variance is the sum of squares of the loading values across the various principal components, which shows in the formula below;

$$PC\ V = \sum \propto_1^2 + \propto_2^2 + \ \ldots \ + \propto_n^2$$

$where;$

$PCV = Total\ Principal\ Component\ Variance\ for\ each\ individual\ component$

$\alpha = Subset\ of\ each\ individual\ component$

$$Total\ Variance = \ PCV1 + PCV2 + PCV3$$

$where;$

$PCV = Total\ Principal\ Component\ Variance\ for\ each\ individual\ component$

By calculating the total variances, it is possible ascertain the correlation between the gases across dumpsites. The order of arrangement considering the emission of these gases in the atmosphere is SPM > NOx > SOx > H_2S > O_3 > CxHy/VOCs > CO.

Table 3. Loading values of 7 parameters in 3 and 2 Principal Components and their total variance.

	Components		
	PC1	PC2	PC3
August 2019[a]			
SPM	0.787	-0.391	-0.445
CO	0.879	0.413	0.228
H_2S	0.163	0.966	0.198
NOx	0.060	0.267	0.945
Sox	0.148	-0.932	-0.322
CxHy/VOC	0.047	0.212	0.960
O_3	0.988	-0.042	0.109
Variance	2.422	2.243	2.219
September 2019[b]			
SPM	-0.666	0.719	
CO	0.362	0.912	
H_2S	0.827	0.200	
NOx	0.885	0.124	
Sox	-0.896	0.097	
CxHy/VOC	0.782	0.192	
O_3	0.105	0.983	
Variance	3.468	2.418	
October 2019[b]			
SPM	-0.581	0.803	
CO	0.429	0.875	
H_2S	0.855	0.196	
NOx	0.880	0.191	
Sox	-0.906	0.086	
CxHy/VOC	0.818	0.047	
O_3	0.140	0.980	
Variance	-0.581	0.803	

Extraction method: Principal Component Analysis, Rotation Method: Varimax Rotation with Kaiser Normalization.
[a] *Rotation converged in 4 iterations*
[b] *Rotation converged in 3 iterations*

Table 4a: Status of ambient air quality at the selected dumpsites

Dumpsite	SPM	CO	NOx	SOx	CxHy/VOC	O_3	AQI	Status
Cemetery Road	816.1	136.3	274.2	0.0	460	22.9	83.2	Polluted
NPA	1069.5	208.3	267.1	0.0	573.4	23.5	96.2	Polluted
Opete	1469.5	416.8	305.8	0.0	533.4	25.5	116.6	Heavily polluted
Refinery Road	1325.0	150.8	285.0	241.7	490.0	23.9	234.4	Severely polluted
Osubi	1294.5	230.0	280.8	280.4	546.6	24.4	263.0	Severely polluted
Okuvo	1622.2	184.25	185.8	307.1	303.4	23.9	223.9	Severely polluted

Table 4b: Air quality Rating based on AQI [1]

Rating	**AQI of ambient air**	**Description of ambient air quality**
A	Below 10	Very clean
B	Between 10- 25	Clean
C	Between 25- 50	Fairly clean
D	Between 50-75	Moderately polluted
E	Between 75-100	Polluted
F	Between 100-125	Heavily polluted
G	Above125	Severely polluted

The average concentration of air pollutants was calculated into the categories of AQI using the standard formulae in Table.4a and Table 4b. In this study, the ambient air shows a high level of pollution in all the selected sites, indicating serious health risk for people living in these areas.

IV. CONCLUSIONS

The resultant pollution of ambient air, including highly harmful toxic substances, had a long-term effect on people living around these dumpsites. The suspended particulate matter (SPM), Hydrogen sulphide (H_2S) and Oxides of Nitrogen (NOx) need urgent attention for remediation of the contaminated sites and new technology for the management of waste should be adapted.

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