Analysis and Evaluation of Pollution Potentials of Gaseous Emissions from a Waste Dumpsite in Ubakala, Umuahia Southeastern Nigeria.

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Abstract

Gaseous emission from Ubakala waste dumpsite in Umuahia area of Abia State was analyzed and evaluated in order to determine the pollution potential. This research was aimed at understanding the pollution dispersion patterns path and impact from source to adjoining communities. Gas samplers/analyzers were used to identify and measure the concentration levels of individual pollutant gases directly in the field in different communities within the study area. The mean relative humidity value ranged from 58.65 % to 77.6 % in the wet season; whereas in the dry season, it ranged from (57.80 % to 64.00 %). The mean relative humidity was generally low during the dry season, while during the wet season, it was generally high within the dumpsite. The wet season show temperature range from 25.40 to 30.70 ^{o} C. The dry season also show temperature range from (32.05 % to 37.65 %) The mean ambient temperature was generally high during the dry season while, during the wet season, it was generally low within the dumpsite. The wind speed ranged from (0.6 ms^{-1}) in the northwest direction to (2.25 ms^{-1}) in the southeast direction. The mean wind speed was generally high during the dry season. During the wet season it was generally low within the dumpsite and also at the control site. In the dry season, the mean concentrations of particulate matters of 74.93 µg/m^3 and 22.60 µg/m^3 were measured at 0.0 km and 3.6 km respectively with average mean concentration of 35.35 µg/m^3. Similarly, in wet season, the mean concentrations of particulate matter 63.50 µg/m^3 and 20 µg/m^3 were measured at 0 km and 3.6 km respectively with average mean concentration of 30.43µg/m^3. The air quality within the study area is poor due to the presence of the waste dump. Pollutants such as CH_4 and CO were below standard whereas H_2S, VOC, SO_2, and NH_3 exceeded the permissible limits recommended by the Federal Ministry of Environment. This condition could result to serious health challenges, even death to man and other living things in the area.

Keywords: *Analysis, Evaluation, Pollution, Potential, Emission, Waste, Dumpsite, Ubakala, Umuahia*

1 Introduction

Solid waste is the term used to describe non-liquid waste materials arising from domestic, trade, commercial, agricultural, industrial activities and from public services (Aibor and Olorunda, 2006; EPA, 2011). Man, in an attempt to satisfy his daily needs, engages in the production of goods and services and in the process of which waste is generated (Beede and Bloom, 1995; Muhammad, 2007).

Dumpsites are locations where waste are deposited and allowed for gradual decomposition of the biodegradation parts of the waste materials on being consumed by bacteria and in the process, gas is released into the surrounding atmosphere (Chen et. al, 2008). These waste materials resulting from human and animal activities that are considered useless, unwanted or hazardous. Papers, vegetable matter, wood, textiles and plastics make up large chunk of waste in modern dumpsite, about 65 % of which is biodegradable (Rushbrook, 2001). The amount of waste produced by human activities is increasing in most parts of the world, accompanied by problems of disposal (Microsoft Encarta Premium Encyclopedia Suite, 2004). The increase in solid waste generation is as a result of continuous economic growth, urbanization and industrialization.

Environmental pollution results from man's quest to adopt contemporary technologies, urbanization, industrialization, with corresponding inefficient waste management strategies (Rajaganapathy, et al. 2011). **Momodu et al. (2011)** and **Angaye and Abowei, (2017)** identified domestic and commercial as the two major sources of MSWs. Air pollution can cause nasal, eyes and airway irritation, wheezing, coughing, anoxia, and even lung and heart problems, which increase risk to asthma and heart attack. 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 **(Barakat-Haddad, 2015).**

AIT (2004) pointed out that final disposal in most of the developing countries is usually a matter of transporting the collected waste to the nearest available open space and discharging them. Jung et al, (2005) argued that open dumping had the potential to reduce environmental quality in neighbourhood and could also pose a threat to public health, the environment and even scavengers that depends on scavenging for their livelihood. The consequences of open dumping associated with environmental and health hazards and risks include: unpalatable odour, dust emissions, poor aesthetics, environmental nuisances, attraction of vermin, vector and pest, severe health risks to human beings and animal, breeding of disease vectors, flies and rats (WHO, 2014; Angaye and Abowei, 2017).

Other methods of waste disposal include: landfilling, incineration, recycling, biological reprocessing processes and reduction method

Pre-school children; waste workers; and workers in facilities producing toxic and infectious material are at risk of improper disposal of solid waste. Also those living close to a waste dump and those whose water supply has become contaminated, either due to waste dumping or leakage from landfill sites, he identified to be at higher risk (**Onakpohor, 2013**). This category of people are predisposed to cardiovascular diseases like bronchitis, lung cancer, cardiovascular disease, birth defect, asthma, and premature mortalities (Agwu and Ozeh, 2013; Abur et al., 2014 Barakat-Haddad, 2015).

Integrated waste management, thus, represents a move away from waste management through impact management and remediation to a proactive management system that focuses on waste prevention and minimization.

Analysis and evaluation of pollution potential of emission from the dumpsite was carried out to understand the pollution dispersion pattern path and impact from source to adjoining communities. Emission of gases from dumpsites is known to be dangerous and harmful to the host environment and the hazards associated thereof are due to the breakdown of organic materials producing methane (CH_4), carbonmonoxide (CO), hydrogen sulphide (H_2S) and other gases. The odor emanating from the dumpsites can cause illness to people living closer to the dump, and also decrease the economic and social values in the locality. Hence, analysizing and evaluating pollution potential of emission from the dumpsite are necessary in providing baseline information on the level of pollutant emission of the dumpsites and the impact on the host environment. Therefore, the objectives of the study are: (1) to identify individual pollutant gases present around the dumpsite; and (2) to determine the concentration levels of these emitted pollutant gases (3) to determine seasonal variation in the concentration levels of pollutant gases (4) to compare the measured pollutants concentrations with standards; and (5) to determine a geospatial variation and trend for the pollutants.

2. Study Area Description and Geology

The study area Mbarakuma Ubakala, is in Umuahia South Local Government, Abia State. It is geographically located within longitudes 7^0 24' and 7^0 30'E and Latitude 5^0 31'N and 5^0 34'N (Figure 1). It is adjoined by Eziama community at the North, Lagura-Ubakala and Omosu at the East, and Abam at the West. The municipal waste dumpsite is located along Umuahia-Aba Road. The dumpsite has an average depth of 3.47 m and a mean surface area of about 4200 m^2 with an estimated capacity of 21, 400 m^2 and has been in use since 1996 just after the creation of Abia State.

The area is part of Benin Formation it has lithologies comprises of sands, silts, gravel and clayey intercalations. The Benin Formation is the water bearing zone of the area. It is overlain by Quaternary deposits (40-150m) thick, and generally consists of rapidly alternating sequences of sand, Silty and clay which latter become increasingly prominent seawards (Etu-Efeotor and Akpokodje, 1990).

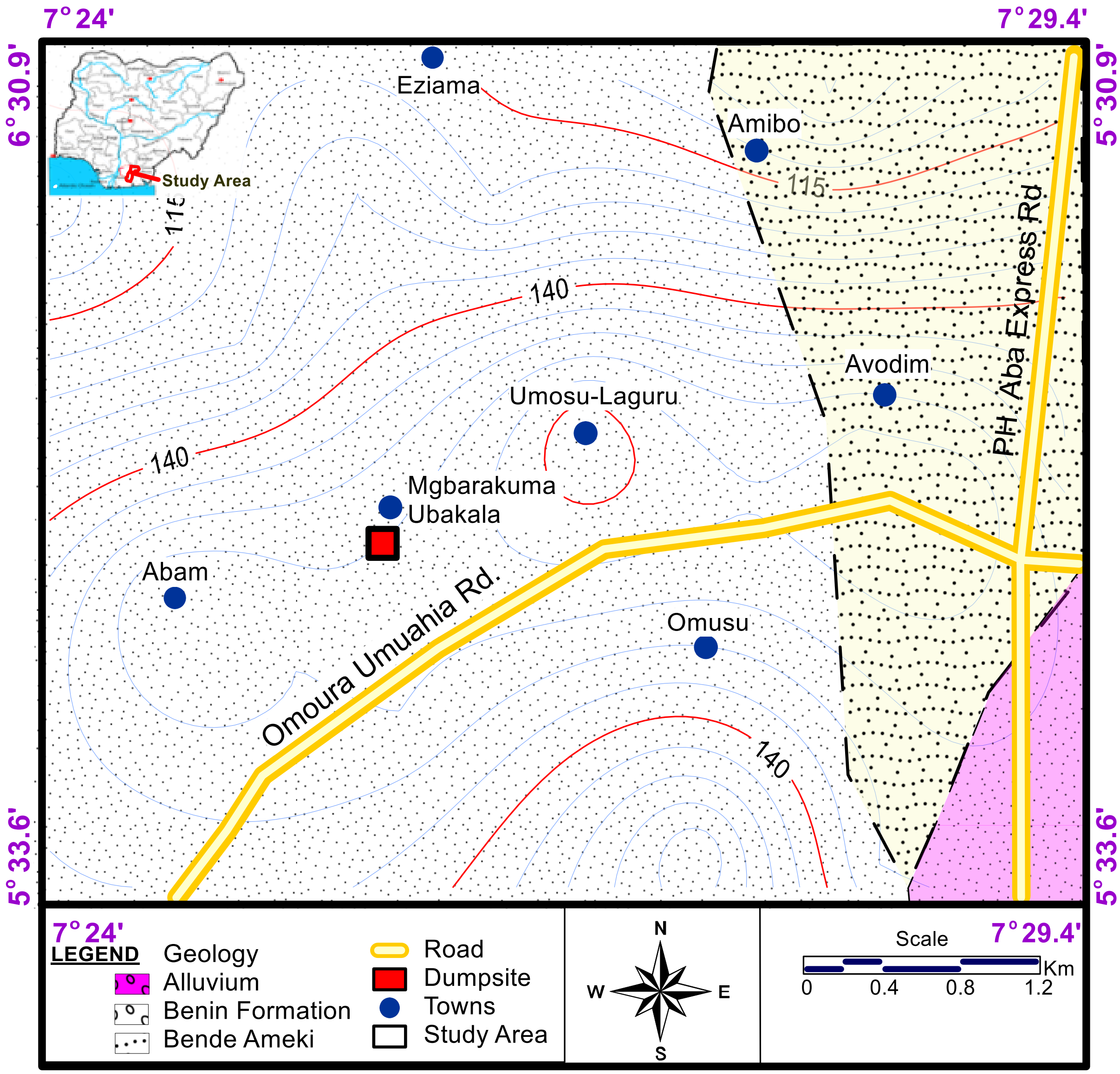


Figure 1: Topographic and Geologic Map Showing the Study Area (Source: Nigerian Geological Survey Agency (NGSA, 2006))

3. Materials and Methods

Potable digital hand held gas Analyzers were used to monitor air quality *in-situ* around Mbarakuma Ubakala waste dump at different locations including; Mbarakuma, Laguru, Abam, Omusu, Eziama, Avodim, Amibo, and the control station (Afara Ibeku) (Figure 1).The sampling equipment used in this study include Geologic and topographic maps, Geographical Positioning system (GPS) used in the measurement of elevation and coordinate (longitudes and latitudes) of the sample locations. Wind Vane was used to determine the prevalent wind direction. Kestrel Model No. 4500 pocket weather tracker was used for the measurement of meteorological parameters; wind speed (m/s), ambient temperature (°C) and Relative Humidity (%). Gas Analyzer (GA-21 Plus Flue) with electronic- chemical sensors was used for the detection of gas concentrations such as SO2 CO, CH_4, and H_2S, A Portable Digital Air Sampler (CH-HAT 200) with sensors was used for the detection of TSPM and Aeroqual series 200 gas monitor with VOCs sensor head was used for the detection of VOCs. Each parameter was measured two (2) times per station at the interval of 30 minutes. Analyzers were used to monitor air quality in-situ at different communities in the wet and dry seasons during the peak and active period of the plant operation within the study area. Also measurement at distance interval of 600m was made along chosen traverse. The air quality implication of the project was determined by comparing the detected and quantified air pollutants from the study with the Nigerian Ambient Air Quality Standard set by the Federal Ministry of Environment (FMEnv), (1991); hydrocarbon – 160 µg/m3 or 0.16ppm, SO2 - 0.1ppm, CO – 10 ppm and PM – 250 µg/m3

.4 Result and Discussion

Table 1: Variations in Relative Humidity, Ambient Temperature, Wind Speed and Direction

Location	Period	Ambient Temp. (° C)		Rel. Humidity (%)		Wind Speed (s)		Wind Direction	
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Mbarakuma Ubakala	Day	26.40	40.2	76	58.6	0.5	0.9	NW	NW
	Night	24.40	36.6	79.2	62.3	0.7	1	NW	NW
	Mean	**25.40**	**38.4**	**77.6**	**60.45**	**0.6**	**0.95**		
Laguru	Day	26.40	39.4	65.6	58.2	0.4	0.9	NW	NW
	Night	25.40	34.6	71.2	63.6	0.8	1	NW	NW
	Mean	**25.90**	**37**	**68.4**	**60.9**	**0.6**	**0.95**		
Abam	Day	26.60	38.4	65.7	60.2	1.3	1.7	NE	NE
	Night	26.00	34.7	68.3	63.5	1.8	1.9	NE	NE
	Mean	**26.30**	**36.55**	**69**	**61.85**	**1.55**	**1.80**		
Omusu	Day	29.30	37.4	69	61.7	1.7	1.9	SE	SE
	Night	28.00	34.7	73.2	66.3	2.3	2.6	SE	SE
	Mean	**28.65**	**36.05**	**71.1**	**64**	**2**	**2.25**		
Eziama	Day	30.20	36.2	60.7	58.1	0.7	1.1	SE	SE
	Night	30.00	33.7	63.3	60.3	1.2	1.6	SE	SE
	Mean	**30.10**	**34.95**	**62**	**59.2**	**0.95**	**1.35**		
Avodim	Day	31.1	35.4	59.6	56.7	0.8	1	SE	SE
	Night	29.4	30.7	61.6	58.9	1.1	1.3	SE	SE
	Mean	**30.25**	**33.05**	**60.6**	**57.8**	**0.95**	**1.15**		
Amibo	Day	32.5	34.4	59.6	57.2	1.5	1.9	NW	NW
	Night	28.9	29.5	61.6	59.6	2.1	2.3	NW	NW
	Mean	**30.7**	**31.95**	**60.6**	**58.4**	**1.71**	**2.10**		
Afara Ibeku/ Control	Day	35.1	37.7	57.8	53.7	1.1	2	SW	SW
	Night	32	36.2	59.8	57.2	1.9	1.4	SW	SW
	Mean	**33.55**	36.95	**58.8**	**55.45**	**1.5**	**1.70**		

Table 2. Average Gaseous Concentration of the pollutant and Federal Ministry of Environment (FME) Standard (2009)

Station		TSPM		H_2S		VOC_S		CO		NH_3		CH_4		SO_2	
		(µg/m³)		Concentration (ppm)											
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
1	Day	68.00	80.24	3.4	4	2.9	2	2.3	2.8	8.00	4.2	0.07	0.11	1.05	1.6
	Night	59.00	69.62	2.8	3	2.6	1.8	1.7	2.2	6.00	3.9	0.05	0.09	0.95	1.4
2	Day	41.00	48.38	2.6	3.2	2	1.7	1.6	2.63	5	3.6	0.06	**0.05**	0.6	1.4
	Night	39.00	46.02	2.4	2.8	2	1.25	1.2	2.31	3	3	0.04	**0.03**	**0.8**	**1**
3	Day	25.00	28.75	2	3.3	1.1	1.07	1.04	2.57	4.6	2.5	0.05	0.07	**0.5**	1
	Night	23.00	26.45	2	2.1	1	0.95	0.76	2.03	3.4	1.5	0.03	0.05	**0.3**	0.8
4	Day	24.00	28.32	1.7	2.2	0.9	0.6	0.68	2.5	4.6	1	0.04	**0.05**	0.7	0.8
	Night	21.00	24.78	1.25	2	0.7	0.8	0.32	1.2	3.2	1.5	0.02	**0.03**	0.5	0.6
5	Day	23.00	25.99	1.22	1.8	0.9	0.8	0.4	1.6	3.2	1	0.03	0.036	**0.5**	0.6
	Night	21.00	23.73	1	1.4	0.6	0.5	0.2	1.3	2	0.6	0.02	0.024	0.3	0.3
6	Day	22.00	24.86	0.7	1.2	0.8	0.7	0.11	1.05	3	0.7	0.016	0.025	0.25	0.3
	Night	20.00	22.60	0.5	0.8	0.6	0.5	0.09	0.95	1.8	0.9	0.012	0.015	0.15	0.2
7	Day	21.00	23.73	0.4	1	0.8	0.6	0	0.76	1.1	1.04	0.01	0.01	0.11	0.2
	Night	19.00	21.47	0.2	0	0.5	0.3	0	0.32	0.9	0.4	0.01	0.01	0.09	0.1
Mean		**30.43**	**35.35**	**1.58**	**2.06**	**1.24**	**0.97**	**0.74**	**1.73**	**3.56**	**1.85**	**0.03**	**0.043**	**0.49**	**0.74**
Average Mean		**32.89**		**1.82**		**1.11**		**1.24**		**2.70**		**0.04**		**0.62**	
FMEn (2009)		250		**0.008**		0.05		**5.0**		**0.2**		**5.0**		**0.01**	

4.1 Meteorological parameters determined

(a) **Relative Humidity (%)**

The mean relative humidity ranges from 58.65 - 77.6% in the wet season. Mgbarakuma and Amibo had the highest (77.6 %) and lowest (58.65%) percentage respectively. The mean relative humidity in dry season ranges from (57.80 - 64.00 %). The mean relative humidity was generally lower in the dry season than the mean relative humidity in the within the dumpsite (Figure 2).

(b) Ambient Temperature (º C)

The mean ambient temperature was generally higher in the dry season than in the wet season. The temperature ranges from 25.40 to 30.70 **º C** in the wet season, while the temperature range from (32.05 -37.65 %) in dry season (Figure 3).

(c) **Wind Speed (S)**

The mean wind speed was generally higher in the dry season than in the wet season (Fig. 4.3).

In the wet season, the prevailing wind speed (2 ms^{-1}) was observed in the southeast direction and lowest (0.6 ms^{-1}) in the northwest direction. In the dry season, the dominant wind speed (2.25 ms^{-1}) was observed in the southeast prevailing direction and lowest (0.95 ms^{-1}) in the northwest direction (figure 3).

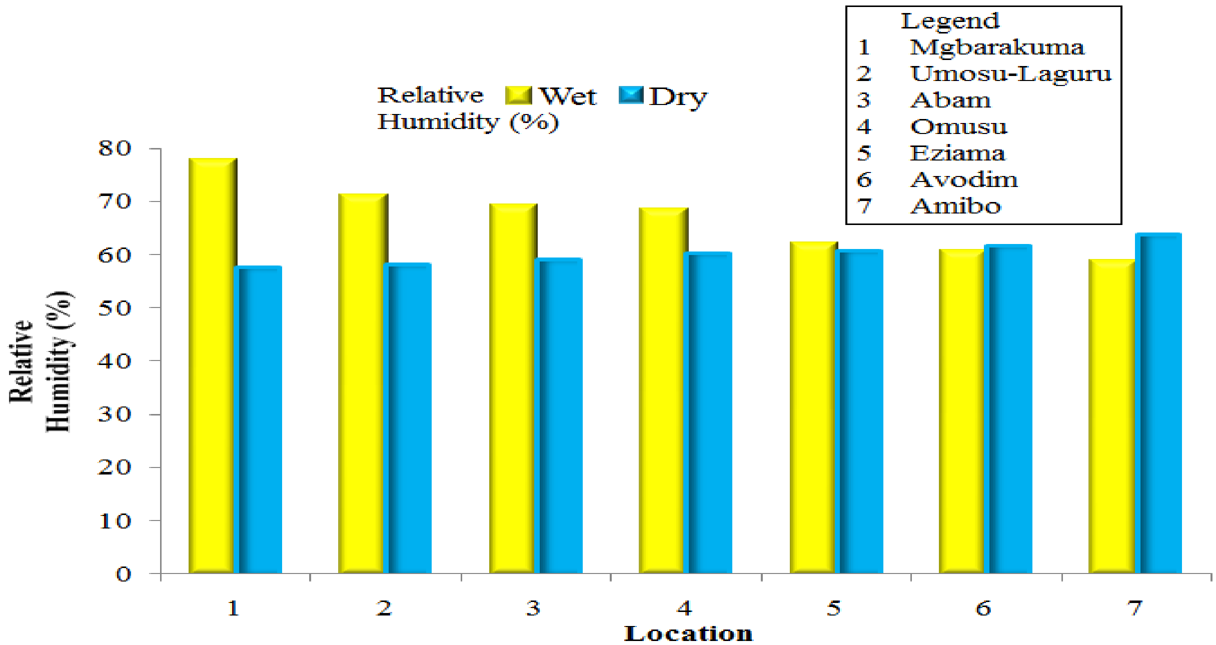


Figure 1: Average Relative Humidity **(%)** at Different stations

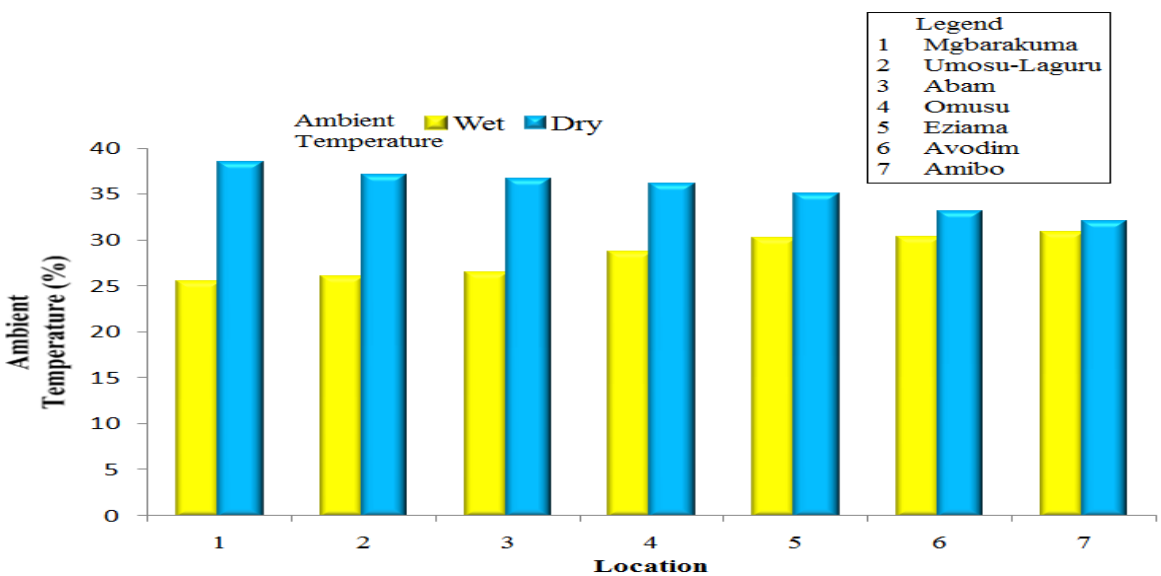


Figure 2. **Ambient Temperature (º C) at Different Stations**

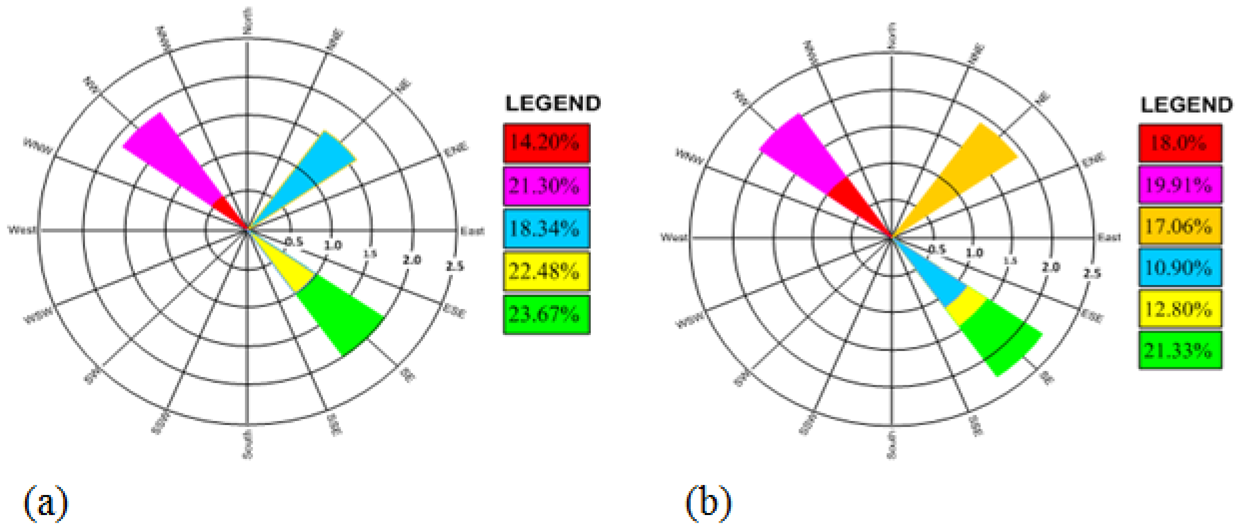


Figure 3. Distribution of Wind Speed and Wind Direction: (a) Wet Season; (b) Dry Season

The wind rose diagrams (Figure. 3) reveal that the prevailing wind in both seasons is in the southeast direction. Wind speed and direction also determine how gas concentration in the air disperses and diffuses at different rates.

Naturally, wind speed and direction determines whether the local residents will perceive waste odour so that the degree of the problem will vary from day to day (Chan et. al, 2008).

4.2 Gases Concentration of the pollutant

(a) Particulate Matter and Gases Concentration

In the dry season, the mean TSPM measured at 0 km and 3.6 km were 74.93 µg/m^3 and 22.6 µg/m^3 respectively. The average mean TSPM was 35.35 µg/m^3. Similarly, in wet season, the mean TSPM measured at 0 km and 3.6 km were 63.5 µg/m^3 and 20 µg/m^3 respectively. The average mean TSPM was 30.43 µg/m^3.

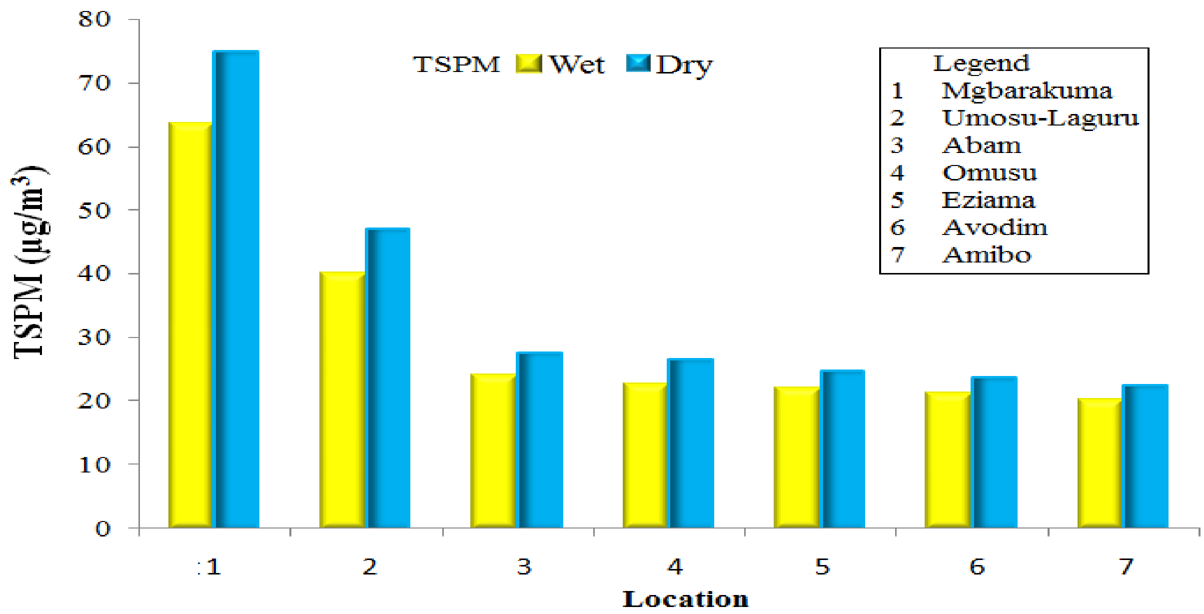


Figure 4 Mean Concentration of TSPM against Locations

The wet season concentrations to be significantly lower than the dry season concentrations. This observation is in consonance with the report by Efel, 2008, Gobo et al, 2009 and Onakpohor, 2013. The average mean TSPM were below 250 µg/m^3 standard (FMEnv., 2009). Air quality on basis of TSPM could be classified as high quality and hence do not pose serious environmental problems (Table 3).

Table 3. Air Quality Classification Based on Total Suspended Particles (TSPM) Values

Range of TSPM Values (µg/m3)	**Class of Air Quality**
0 – 75	High Quality
76 – 230	Moderate Quality
231 – 600	Poor Quality

Source: Ibe et. al (2017)

(b) **Sulphur Dioxide (SO_2)**

The concentration of SO_2 in the dry season is higher than the concentration in the wet season. The concentration of SO_2 measured in wet season ranged from 0.1 to 1.0 ppm while concentration in dry season ranged from 0.15 to 1.5 ppm. In both seasons, the concentration decrease away from the source (Figure 5).

(c) **Carbon Monoxide (CO)**

The concentration of CO in the dry season is higher than the concentration in the wet season. The concentration of CO measured in wet season (0 - 2 ppm) while, the concentration in dry season ranged from 0.54 to 2.5 ppm (Figure 6).

(d) **Methane (CH_4)**

The concentration of Methane in the dry season is higher than the concentration in the wet season. Methane concentration measured in wet season ranged from 0.01 to 0.06 ppm. the dry season concentration ranged from 0.01 to 0.1 ppm (Figure 7).

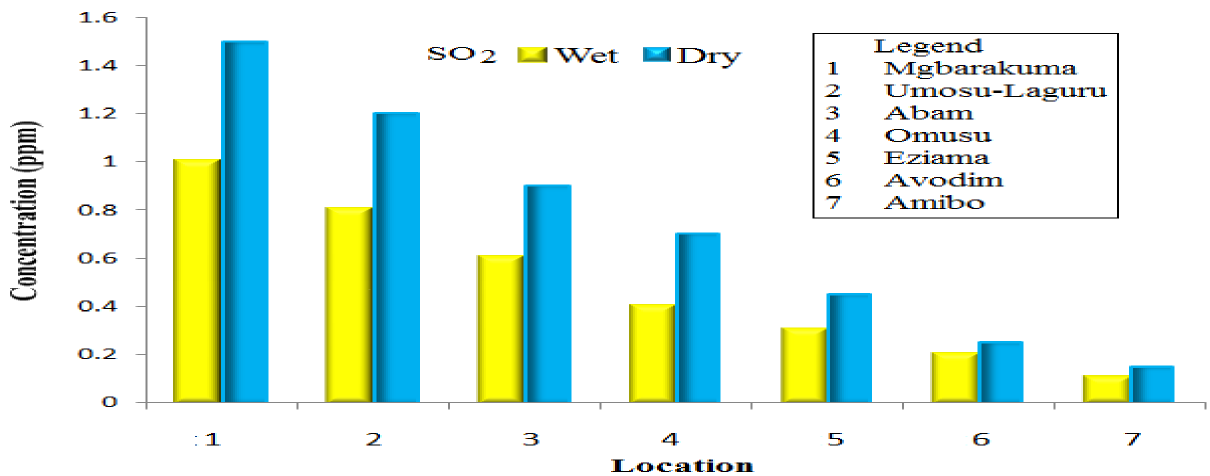


Figure 5 Concentration of Sulphur (iv) oxide (ppm) at Different Stations

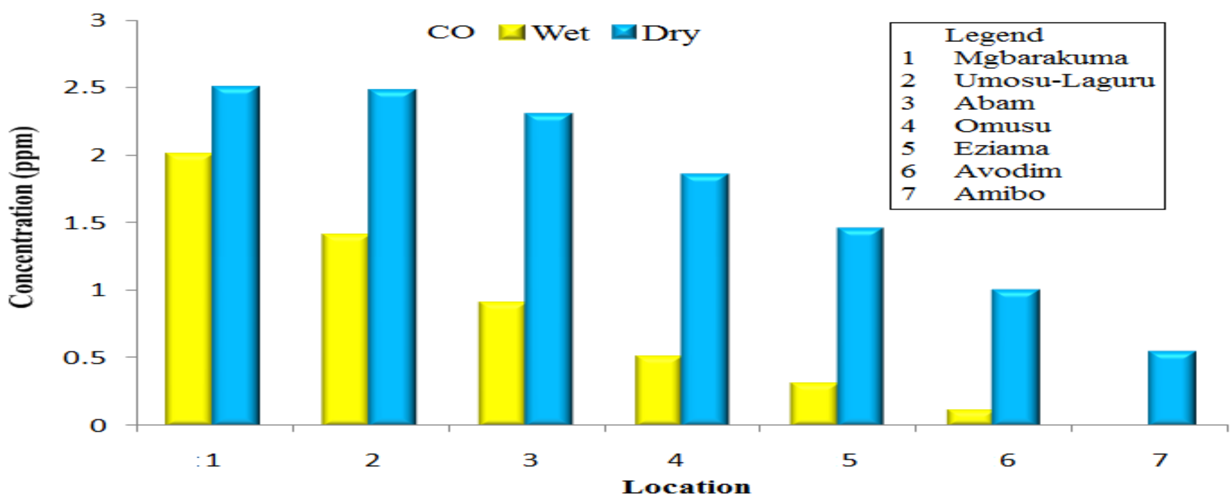


Figure 6 Concentration of Carbon monoxide (ppm) at Different Stations

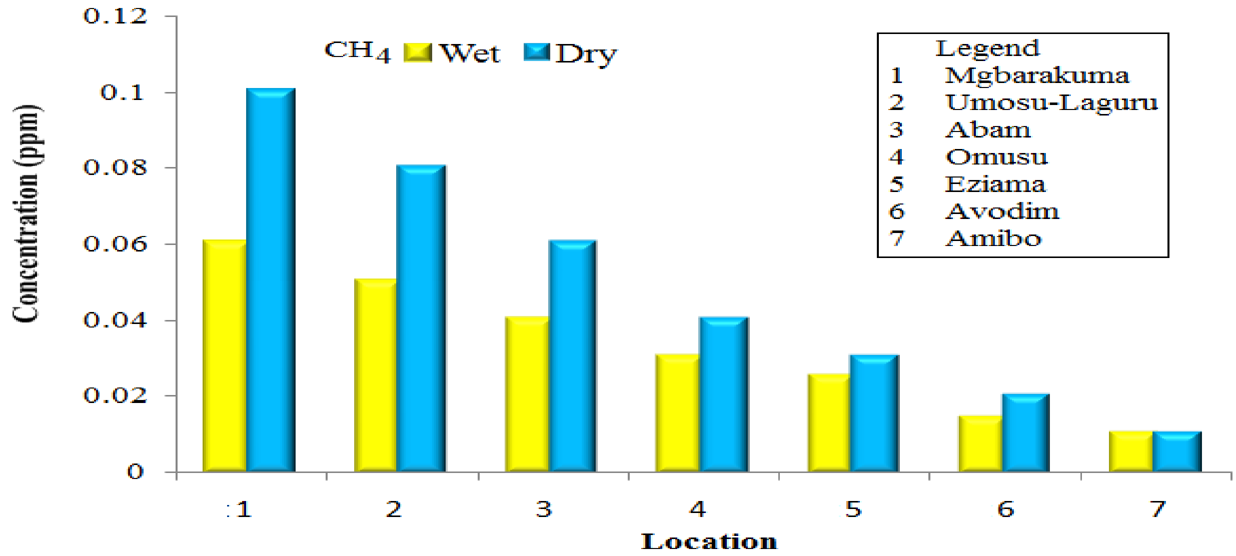


Figure 7 Concentration of Methane (ppm) at Different Stations

(e) **Hydrogen Sulphide (H_2S)**

The concentration of Hydrogen Sulphide (H_2S) measured during the wet season ranged from 0.3 to 3.1 ppm; the dry season concentration ranged from 0.5 to 3.5 ppm (Figure 8).

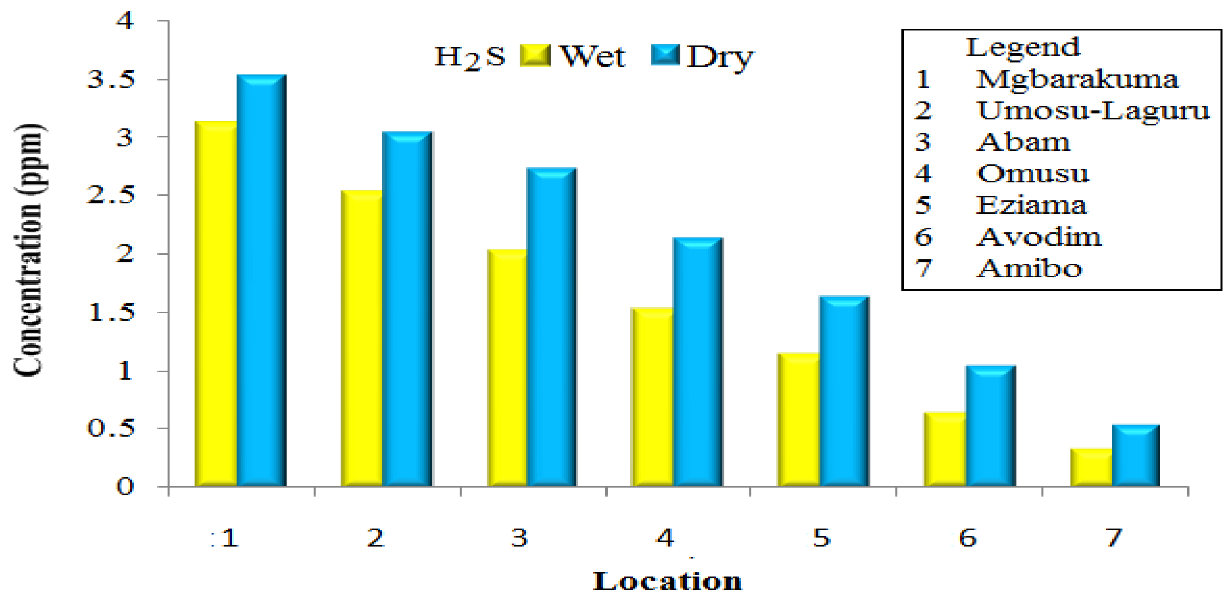


Figure 8 Concentration of Hydrogen Sulphide (ppm) at Different Location

(f) **Ammonia (NH_3)**

Ammonia concentration measured during the wet season ranged from 1 to 5.53 ppm. The dry season concentration ranged from 0.72 to 4.05 ppm (Figure 9).

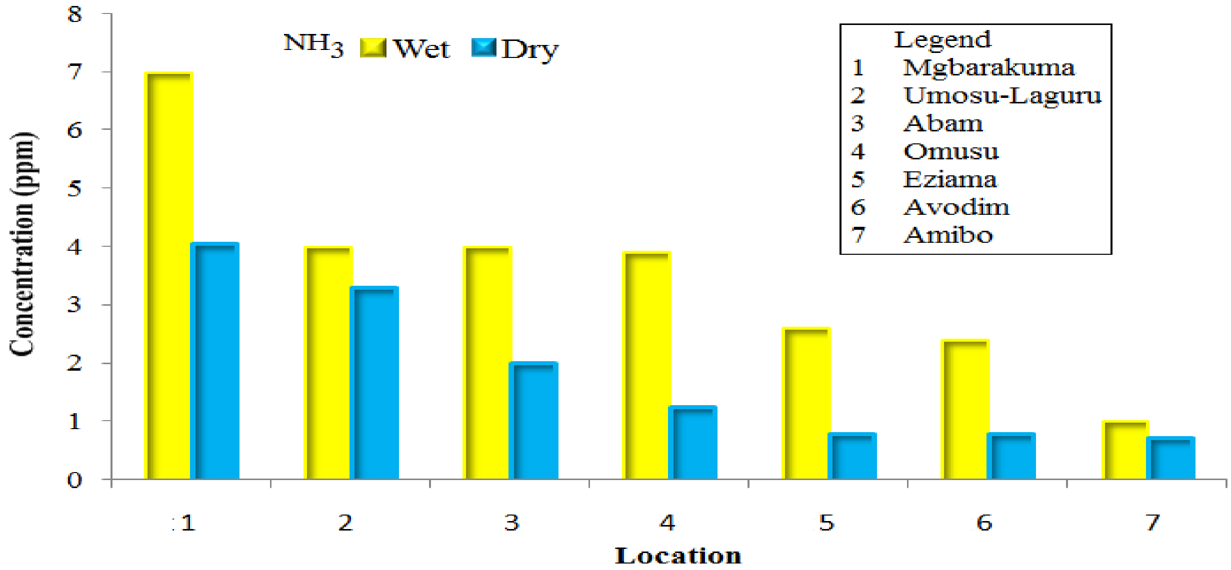


Figure 9 Concentration of Ammonia (ppm) at Different Stations

(g) Volatile Organic Compounds (VOC)

VOC concentration measured during the wet season ranged from 0.65 to 2.75 ppm. Similarly, the dry season concentration ranged from 0.45 to 1.9 ppm (Figure 10).

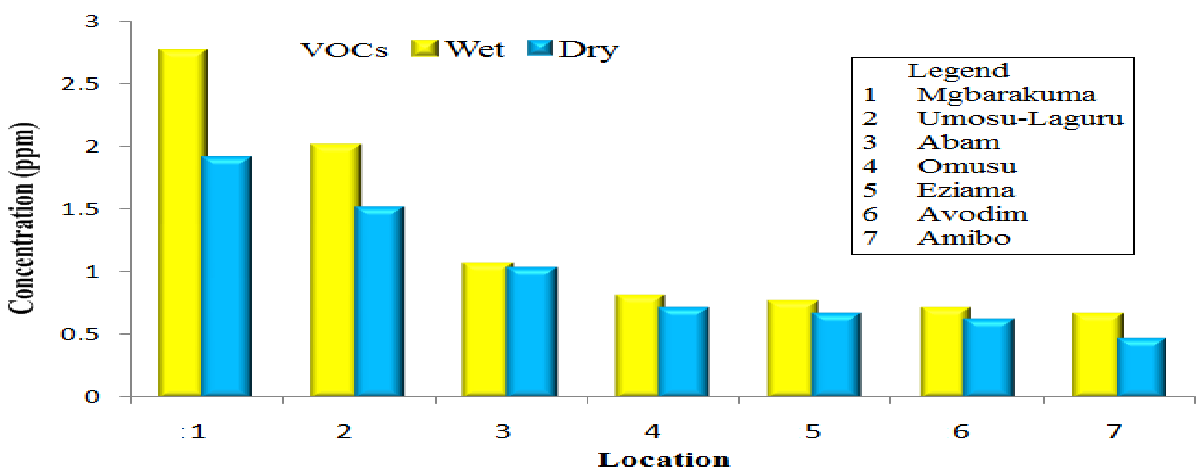


Figure 10 Concentration of VOC (ppm) at Different Stations

The average mean concentrations of **H_2S** (1.82 ppm), **VOCs** (1.11 ppm), **NH_3** (2.70 ppm) and **SO_2** (0.62 ppm) recorded across the study area for both seasons exceeded their permissible limits. Whereas, **CO** (1.24 ppm) and **CH_4** (0.04 ppm) were below standard (Table 4). These levels of pollutants are of serious environmental concern for residents living close to dumpsites, waste workers, scavengers, etc.

4.3 **Percentage of Emission of Various Gases**

The total gaseous emission at the Ubakala dumpsite at both seasons was up to 7.35 ppm. The Chart shows percentage (%) emission of various gaseous pollutants (Figure 11)

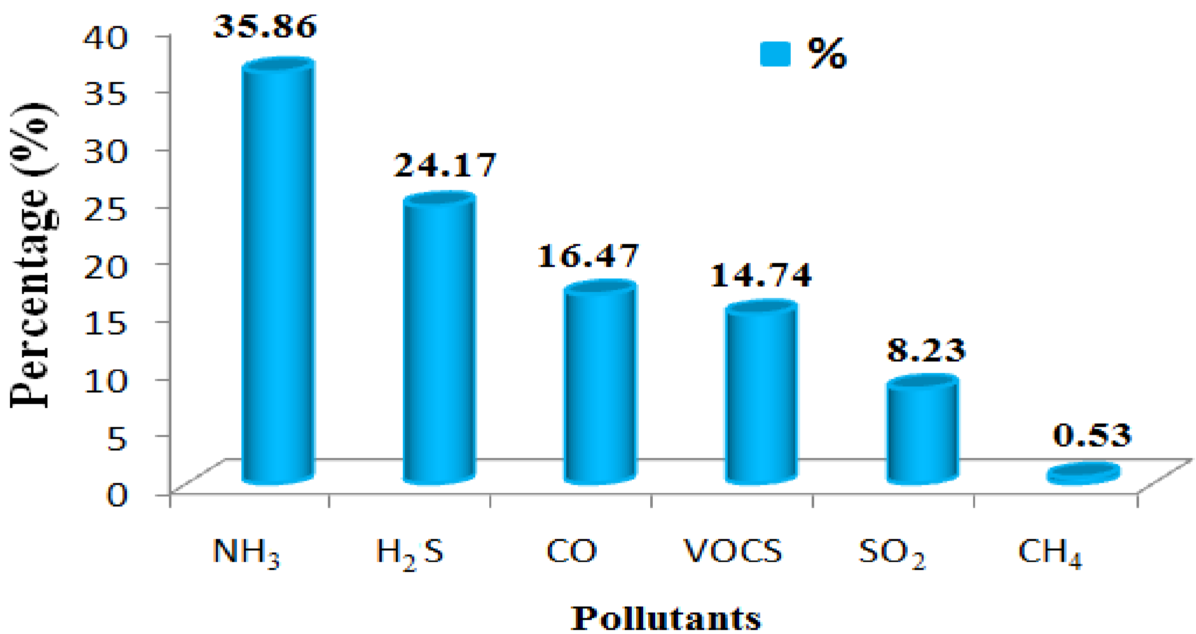


Figure 11: Shows (%) Emission of various Gaseous Pollutants

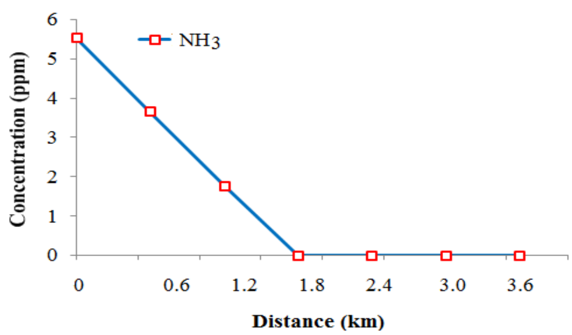
4.4 The Dispersion and Dilution Model

The concentrations of different gases using regular distance intervals to determine a zero or minimum positive concentration called the point of dilution of gases away from the dumpsite at a given distance. A simple linear regression model (Y =a + bx) was employed to achieve the target.

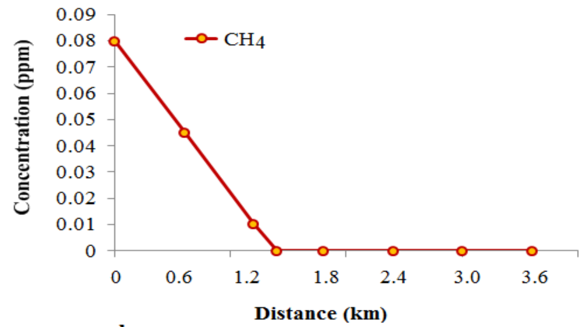
Where "a" =intercept on y and b" = coefficient of regression (Predictor). Distance (X) and concentration (Y) variables were then determined by substituting the values of "a" and "b" into eq. to obtain the regression model equation.

Table 4 Mean Concentration of Gases with their Corresponding Distances (Experimental)

S/N	Dist. (Km)	H_2S (ppm)	VOC (ppm)	CO (ppm)	NH_3 (ppm)	CH_4 (ppm)	SO_2 (ppm)	Sum of the gases
1	0	3.3	2.325	2.25	5.525	0.08	1.25	14.73
2	0.6	2.75	1.738	1.935	3.65	0.045	0.504	10.622
3	1.2	2.35	0.736	1.6	3.00	0.05	0.65	8.386
4	1.8	1.788	0.75	1.175	2.575	0.035	0.65	6.973
5	2.4	1.355	0.7	0.875	1.7	0.028	0.258	4.916
6	3.0	0.8	0.65	0.55	1.6	0.017	0.225	3.842
7	3.6	0.4	0.55	0.27	0.86	0.01	0.125	2.215



a.



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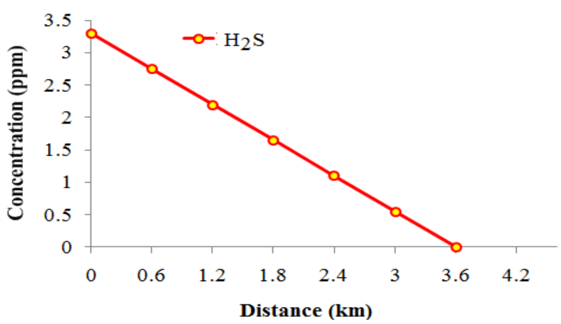

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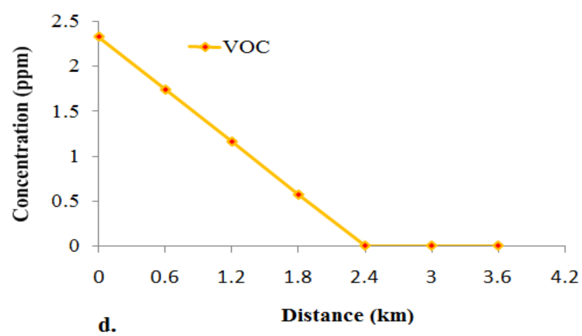

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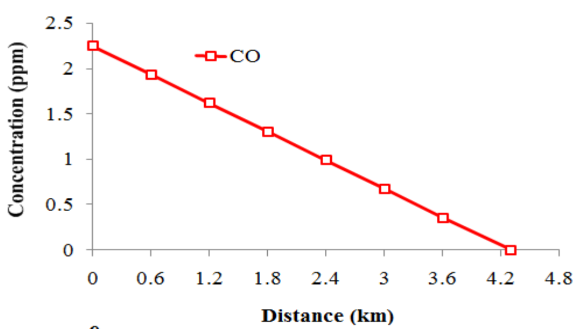
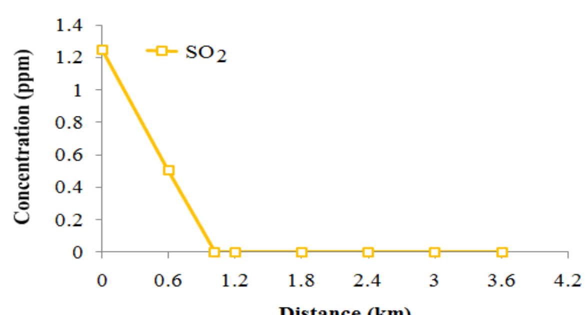


e.



f.

Figure 12: Effect of Distance on the concentration of Gaseous Air Pollutants

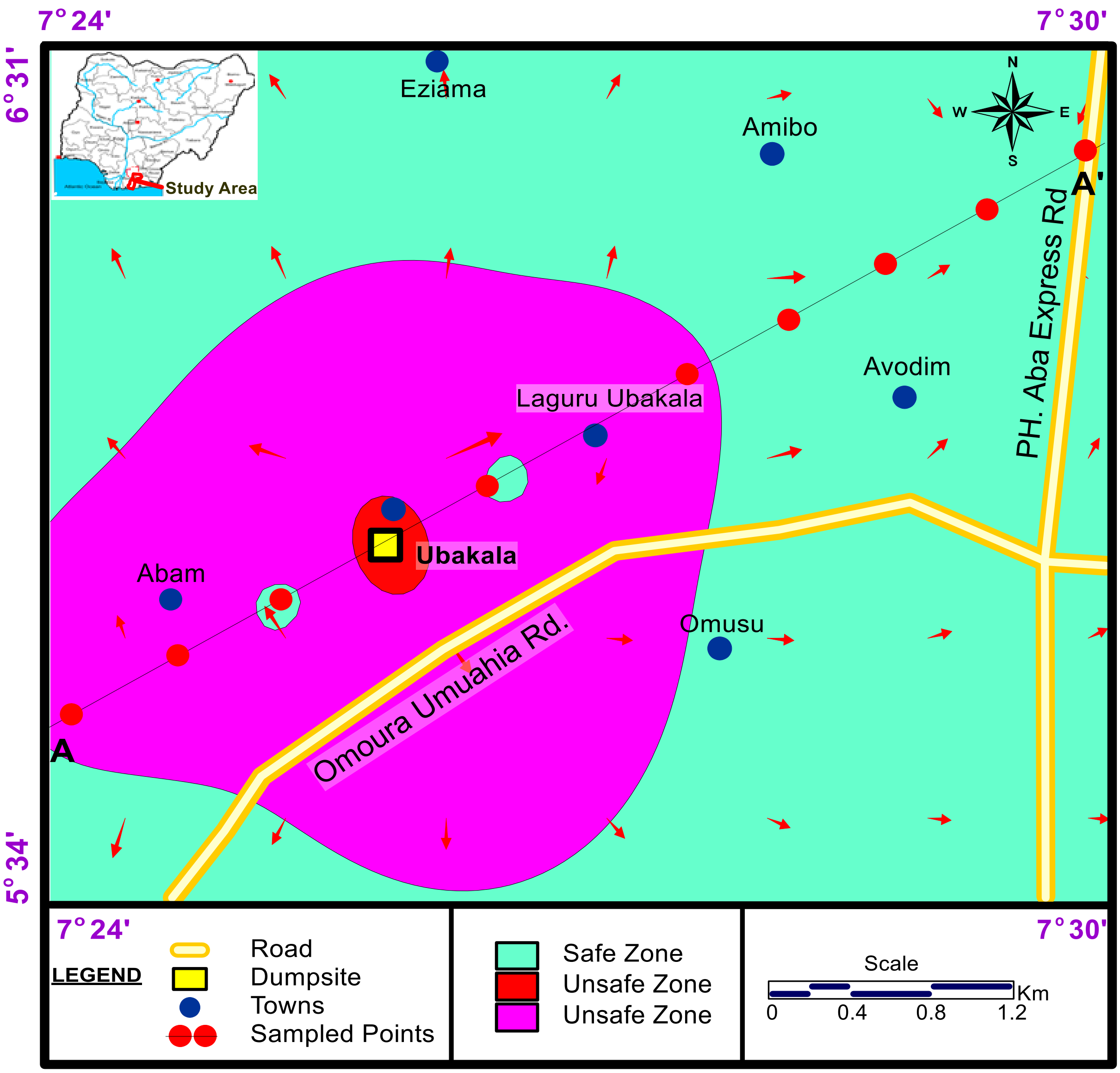


Figure 13 Spatial Dispersion Pollutants

The rates of diffusion reveal that SO_2 diffuses at - 1.238 ppm/km, VOC (- 0.971 ppm/km), H_2S (- 0.917 ppm/km), CO (- 0.523 ppm/km), NH_3 (- 3.072 ppm/km), and CH_4 (-0.057 ppm/km) respectively.

Therefore, **Ammonia** has the highest rate of diffusion (**3.072** ppm/km). This implied that ammonia dilutes faster and does not stay so long in the environment. Methane has the lowest rate of diffusion

(0.057 ppm/km) and as a result, does not disperse and dilute so easily. That is, it can stay for so long in the environment.

5. Conclusions

The air quality within the study area is poor due to the presence of the waste dump. Pollutants such as CH_4 and CO were below standard whereas H_2S, VOC, SO_2, and NH_3, exceeded the permissible limits recommended by the Federal Ministry of Environment. This condition could result to serious health challenges, even death to man and other living things in the area. The concentration of these gases dispersed at different rates and decreased away from the source to varying points of dilution at different distances. These distances indicate the safest points to which habitation can take place.

Suggestions/Recommendations

I suggest that residential buildings should not be sited within 1.2km radius from the dumpsite. As this region is not safe for habitation. This approach will ensure basic sanitary and hygienic conditions. Emission of carbon (iv) oxide from the dumpsite site should be controlled through a landfill gas management system so as to reduce the health effects. Government should build waste recycling plant so as to recycle the recyclables to reduce the quantity of waste dispose to waste dumps. This will lead to job creation for the unemployed through waste to wealth programmes.

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