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Effect of Waste Dumpsite Pollutant Emission on Air Quality in the Federal Capital Territory, Nigeria.

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Abstract:
Municipal Solid Waste (MSW) in the Federal Capital Territory has resulted in serious environmental and health problems due to improper management. Air Pollution is from waste dumpsites is one of the major environmental concerns in FCT due to the disposal system and uncontrolled burning of MSW. Effect of Waste Dumpsite pollutant emission on Air Quality in the FCT was investigated. Concentration level of six (6) air quality parameters which include methane (CH_4), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), hydrogen sulphide (H_2S) and carbon dioxide (CO_2) were determined in the wet and dry season period in eleven (11) dumpsites and three (3) randomly selected non-dump (control) sites in the FCT were determined using a series of hand-held air quality monitoring equipment. Results indicate that levels of CH_4 ranged between 0.0000 mg/m^3 to 0.1699 mg/m^3 and 0.0000mg/m^3 to 0.0638 mg/m^3 for the wet and dry seasons respectively. The wet season mean concentration range for NO_2 was 0.0157 mg/m^3 to 2.0218 mg/m^3, while it was 0.0000mg/m^3 to 1.0035 mg/m^3 for the dry season. The levels of SO_2 ranged between 0.1092 mg/m^3 to 1.8122 mg/m^3 in the wet season and 0.0000 mg/m^3 to 0.3639 mg/m^3 for the dry season. Concentration level of CO ranged between 0.0862 mg/m^3 to 1.9005 mg/m^3 and 0.1114 mg/m^3 to 14.0638 mg/m^3 for the wet and dry seasons respectively. H_2S ranged 0.0232 mg/m^3 to 0.4404 mg/m^3 during the wet season and 0.0232 mg/m^3 to 0.4065 mg/m^3 for the dry season. While that of CO_2 ranged between 1.7669 g/m^3 to 2.3802 g/m3 for wet season and 1.6365 g/m^3 to 1.9923 g/m^3. On the whole, concentration of most measured gases was higher at the dumpsites relative to the control points. Test of Correlation analysis reveal that most of the gas pollutants showed positive significant correlation at 95% and 99% confidence interval. F-value was greater than F-critical at $\alpha<0.01$, which indicated a significant difference in concentration of air quality parameters between the wet and dry seasons. Open dumping and uncontrolled fires in the study area could threaten the health of human life especially the dumpsite workers and the neighbourhood who are regularly exposed to these pollutants. The levels of SO_2, CO, H_2S and CO_2 were above NESREA & FEPA permissible limits while CH_4 and NO_2 were within the standards in both wet and dry seasons. There is a need to develop better practices with regard to municipal solid waste open dump site operation and emission control.
Keywords: Air Pollution, Uncontrolled fire, Waste dumpsite, Municipal Solid Waste, Sustainable Development.

Introduction

Clean air is one of the basic requirements of human existence. However, Air pollution is the contamination of the indoor or outdoor air by a range of gasses and solids that modify its natural characteristics. Key health harmful pollutants include particulate matter (PM2.5 and PM10), carbon monoxide (CO), ozone (O_3), black carbon (BC), sulfur dioxide and nitrogen oxides (NOx). Air pollution is often not visible to the naked eye as the size of the pollutants are smaller than the human eye can detect. The fact that you cannot see the air pollution does not mean that it does not exist (WHO, 2018).

World over, air pollution is a matter of concern at all levels. Municipal solid waste management (MSWM) has become a global challenge which has ranged from local/regional/national in scope, owing to the rapid population growth, urbanization and industrialization. This challenge has acquired an alarming dimension and increasing day by day especially in the developing countries during the last few decades which results into a direct threat to the environmental and public health (Chatterjee, 2010).

The problem of waste disposal in the FCT is ominous as it is pervasive. The management of urban solid waste has become a serious problem with the majority of waste collected simply disposed of in open dumps that are rarely well planned or managed, with the dumpsites being characterized by the emission of greenhouse and

other gases, and nuisance effects which are tracers to health and environmental impacts of poor solid waste management. Malicious odour emanating due to the degradation of the waste in the dumpsite has nuisance effect and decreases the economic and social values in the locality. Njoku, (2015) examined the effects of waste dumpsites on the water and air qualities in Abakaliki, and reported that air and water nearer to dumpsites recorded higher concentration of pollutants than control. There was a significant ($p<0.05$) difference in the concentration of CO, H_2S and NO_2 and a non-significant ($p<0.05$) change in NH_3 in the dumpsites studied. The air nearer to dumpsites recorded higher values for pollutants than the control points.

Weli *et al*, (2014) worked on air quality in the vicinity of a landfill site in Port Harcourt, result showed that temperature and relative humidity influenced the concentration of NO_2, NH_3 and H_2S. Wind speed influences the level of concentrations of SO_2 and Volatile Organic Compounds (VOC). The research attributed the calmness to the dry season when the data was collected. Inadequate management of MSW in most cities of developing countries leads to problems that impair human and animal health and ultimately result in economic, environmental and biological losses (Sharholy *et al*, 2008).

The study assesses the effect of Waste Dumpsite pollutant emission on Air Quality 11 government approved dumpsites in the FCT, Nigeria, within the wet and dry seasons.

The Study Area

The FCT is located between latitude 8^0 25 and 9^0 25 North of the equator and longitude 6^0 45 and 7^0 45 East of Greenwich Meridian (Figure 1). The territory covers approximately an area of 8,000 square kilometres and occupies about 0.87% of Nigeria. The territory is bordered by four states namely; Niger to the West, and North West, Nassarawa to the East, Kogi to the South and Kaduna to the North of the territory (Magaji, 2009).

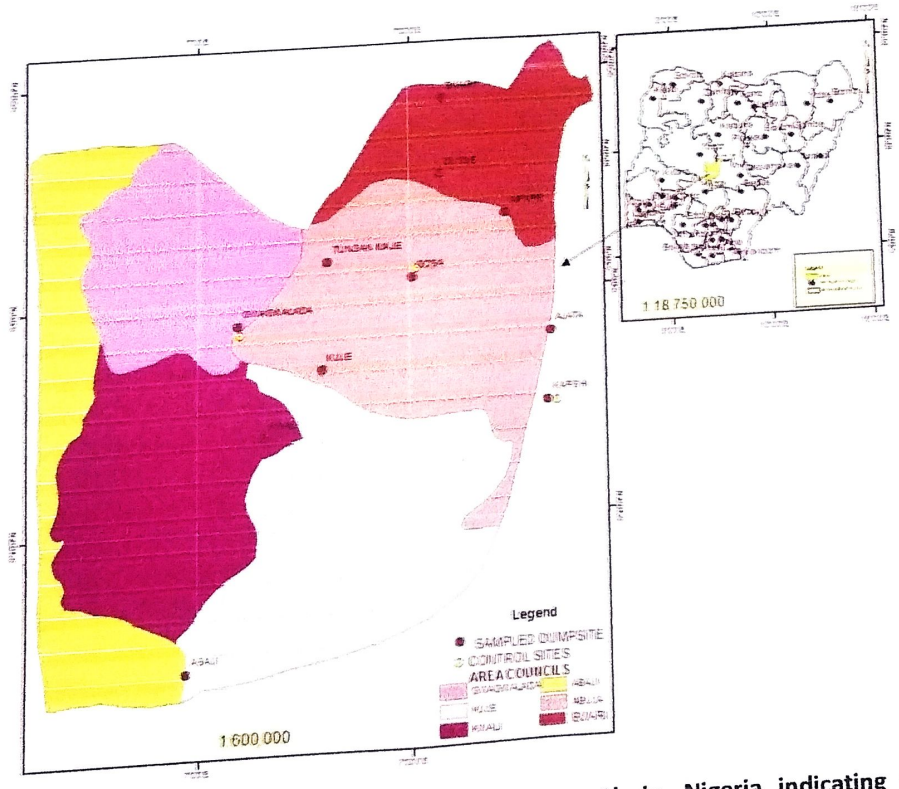

Figure 1: The Study Area (Federal Capital Territory, Abuja, Nigeria indicating the designated Dumpsites and Control Points)

Table 1 Dumpsites, Control Sites with their Locational Attributes

Dumpsite	Classification Remarks	Code	Latitude	Longitude	Elevation (m)
KUJE	+, α	KUJ	8.89392	7.19637	314
TUNGAN MAJE	+, α	TGM	9.05452	7.20566	332
DUTSE	+, α	DTS	9.17816	7.38310	475
AJATA	*, α	AJT	8.93323	7.56084	416
KARSHI	+, α	KSH	8.83053	7.55398	400
BWARI	+, α	BWR	9.29340	7.38813	565
GOSA	+, μ	GSA	9.02511	7.33994	387
MPAPE	*, μ	MPP	9.11455	7.48980	568
KWALI	+, α	KWL	8.79805	7.10252	190
GWAGWALADA	+, α	GLD	8.96625	7.06330	218
ABAJI	+, α	ABJ	8.46129	6.98303	172
GOSA CONTROL	-	GSA CONT	9.03797	7.34518	410
GWAGWALADA CONTROL	-	GLD CONT	8.95181	7.06561	211
KARSHI CONTROL	-	KSH CONT	8.82879	7.56674	360

Source: Oluyori, 2017

Key

- Status of Dumpsite
  - *= Dumpsites that have been closed, investigation was on post closure impact.
  - += Dumpsites that are open and active, measured for current impact level.
  - -= Not Available.
- Methods of Waste Dumping
  - α= Open Dumping
  - μ= Controlled Dumping

Table 1 gives a summary of the locational attributes of the dumpsites and the selected research control sites, there are also information about the waste dumping methods implored in the dumpsites as well as the status of the dumpsites.

Materials and Methods

Identified air quality data were collected for six (6) specific air quality monitoring parameters; carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), methane (CH_4) and hydrogen sulphide (H_2S) in eleven (11) dumpsites and three (3) randomly selected non-dump (control) sites in the FCT using hand held air quality monitoring devices for a period of two (2) seasons. The Portable Real-Time Monitoring Technique was used in measuring concentrations of gases coming directly from the dumpsites (Gas Source emissions) and concentrations of gases in ambient air around (Porter and Tepe, 2013). This was evaluated both during the dry and wet seasons within a year, in each of the identified waste dumpsite.

Sampling frequency to measure levels of H_2S, CO, CO_2, NO_2, SO_2 and CH_4 was twice weekly as adopted from Verere *et al.* (2015), using Crowcon Gas Pro Multigas Detector Gas Alert monitor, Kane-May Single Gas Analysers models SGA93, SGA94 and SGA96. Measurements were out by holding the mobile devices to a height of about one meter above the ground and readings recorded at stability. Data was collected twice weekly between the hours of 6.30 to 9.30am for 3 months in each season in the 11 dumpsites, wet season samples were collected in the months of May, August and October, 2017 while dry season samples were collected in December, 2017, January, and March, 2018 with respect to distance from the centre of the dumpsite towards the adjoining areas.

Results and Discussions

The mean concentration of gases in the study area during the wet and dry seasons are presented in Tables 2 and 3 respectively. From Table 2, maximum mean concentration for CH_4 was 0.1699 mg/m^3 at GSA, while the gas was 0.0000 mg/m^3 at DTS, TGM, KWL, ABJ and the control point during the wet season. The concentration

of NO_2 ranged from 0.0157 mg/m³ at ABJ to 2.0218 mg/m³ at GSA. The pattern of variation of NO_2 in the study area was observed to be GSA>KSH>KUJ>AJT>BWR>KWL>MPP>DTS>TGM>GLD=ABJ. Mean concentration of SO_2 was 1.8122 mg/m³ at GSA, 0.5240 mg/m³ at KSH, 0.4640 mg/m³ at AJT, 0.3712 mg/m³ at MPP, 0.8551 mg/m³ at BWR, 0.6550 mg/m³ at DTS, 0.1092 mg/m³ at TGM, 0.6987 mg/m³ at GLD, 0.4585 mg/m³ at KUJ, 0.3718 mg/m³ at KWL and 0.3493 mg/m³ at ABJ. The highest concentration of CO in the wet season was 1.9005 mg/m³ was in GSA while KSH (0.0862 mg/m³) showed the least concentration of the gas. However, mean concentration of CO at GSA was also comparable to that recorded at BWR (1. 0503 mg/m³). The maximum concentration of H_2S in the wet season within the study area was recorded at GSA (0.4404 mg/m³) which is closely followed by GLD (0.4172 mg/m³) while the minimum concentration (0.0232 mg/m³) was observed at ABJ. Mean concentration of CO_2 ranged from 1.7669 mg/m3 at KUJ to 2.3802 g/m³ at GSA. The mean concentration of gases in the control site were generally lower than obtained results in dumpsites during the wet season.

The concentration of CH_4 and NO_2 in all the dumpsites were below the permissible guideline by FEPA & NESREA, all concentration values for CO_2 in the dumpsite and control point exceeded the permissible limits by FEPA. Concentration of other pollutants SO_2, CO and H_2S were higher than FEPA and NESREA permissible limit in most of the dumpsites (Table 2) during the wet season.

Table 2: Mean of the Air Quality Parameters for the Wet Season in the Study Area.

Dumpsite	CH_4 (mg/m³)	NO_2 (mg/m³)	SO_2 (mg/m³)	CO (mg/m³)	H_2S (mg/m³)	CO_2 (g/m³)
GSA	0.1699	2.0218	1.8122	1.9005	0.4404	2.3802
KSH	0.0274	0.7051	0.5240	0.0862	0.0464	2.0063
AJT	0.0069	0.3329	0.4640	0.0957	0.0579	1.9419
MPP	0.0110	0.1567	0.3712	0.7355	0.1391	2.2356
BWR	0.0275	0.2089	0.8551	1.0503	0.3285	2.1956
DTS	0.0000	0.1410	0.6550	0.1530	0.0812	2.0862
TGM	0.0000	0.0979	0.1092	0.1300	0.1158	2.3743
GLD	0.0275	0.0157	0.6987	0.6590	0.4172	2.1804
KUJ	0.0110	0.3603	0.4585	0.2678	0.3135	1.7669
KWL	0.0000	0.1828	0.3718	0.1117	0.0990	1.8198
ABJ	0.0000	0.0157	0.3493	0.1243	0.0232	1.8989
CONTROL	0.0000	0.0000	0.0086	0.0160	0.0301	1.6815
MAX	0.1699	2.0218	1.8122	1.9005	0.4404	2.3802
MIN	0.0000	0.0157	0.1092	0.0862	0.0232	1.7669
FEPA/NESREA Guideline	656.16*	262**	0.35**	0.2**	0.1*	0.7146*

Source: Oluyori, 2017 *** FEPA GUIDELINE** ****NESREA GUIDELINE**

A summary of mean concentration can be seen in Table 3, concentration of CH_4 ranged from 0.0000 mg/m³ at DTS, KWL and ABJ to 0.0638 mg/m³ at GSA. The maximum mean value of SO_2 was observed in KWL (0.3639 mg/m³) whereas the minimum value was at BWR, TGM and ABJ (0.0000 mg/m³). The mean concentration of CO in the dry season ranged from 0.1114 mg/m³ at KWL to 14.8457 mg/m³ at GSA, the pattern observed was GSA>BWR>KSH>GLD>MPP>AJT>TGM>DTS>KUJ>ABJ>KWL. The highest mean concentration of H_2S was (0.4065 mg/m³) at GSA while the lowest concentration (0.0232 mg/m³) was at MPP. Concentration of CO_2 ranged between 1.6365 g/m³ and 1.9923 g/m³ in AJT and GLD respectively. The level of concentration of the gases at the control point is lower than concentration at the dumpsites. The concentration of CH_4, NO_2 and SO_2 were below the permissible of FEPA and NESREA while concentration of pollutants like CO, H_2S and CO_2 were higher in all the dumpsites (Table 3). Values of the air quality parameters were generally lower in the control site than the dumpsites during the dry season.

Table 3: Mean of the Air Quality Parameters for the Dry Season in the Study Area.

Dumpsite	CH_4 (mg/m^3)	NO_2 (mg/m^3)	SO_2 (mg/m^3)	CO (mg/m^3)	H_2S (mg/m^3)	CO_2 (g/m^3)
GSA	0.0638	1.0035	0.3057	14.8457	0.4065	1.9322
KSH	0.0164	0.4077	0.3057	4.3726	0.3368	1.7673
AJT	0.0068	0.6468	0.1910	0.8053	0.0436	1.6365
MPP	0.0055	0.2195	0.0218	0.8688	0.0232	1.7861
BWR	0.0273	0.1045	0.0000	5.1793	0.1839	1.8310
DTS	0.0000	0.0314	0.0655	0.5346	0.0465	1.7609
TGM	0.0000	0.0000	0.0000	0.6086	0.0436	1.8833
GLD	0.0219	0.1725	0.0218	1.5657	0.1974	1.9923
KUJ	0.0055	0.2195	0.0655	0.4869	0.0813	1.8836
KWL	0.0000	0.1829	0.3639	0.1114	0.0968	1.9240
ABJ	0.0000	0.1568	0.0000	0.3341	0.0834	1.8686
CONTROL	0.0000	0.0122	0.0000	0.0000	0.0194	1.5070
MAX	0.0638	1.0035	0.3639	14.8457	0.4065	1.9923
MIN	0.0000	0.0000	0.0000	0.1114	0.0232	1.6365
FEPA/NESREA Guideline	656.16*	262**	0.35**	0.2**	0.1*	0.7146*

Source: Oluyori, 2017 * FEPA GUIDELINE **NESREA GUIDELINE

Seasonal Variation

The mean concentration level of CH_4 in the study area for both the wet and dry season were observed to vary, wet season values were higher than the dry season, GSA recorded the highest mean value for both seasons, this implies that the emission concentration of CH_4 is significantly different in GSA from other dumpsites, the upper limit of the range is higher than values reported by Weli & Adekunle, (2014). This can be attributed to the composition and quantity of waste that is received by this dumpsite, CH_4 is considered as an asphyxia and is the constituent of gas that is likely to pose the greatest explosion hazard.

The levels of NO_2 in the wet season ranged between (0.0157 mg/m^3 to 2.0218 mg/m^3), while it was (0.0000mg/m^3 to 1.0035 mg/m^3) for the dry season. The observed minimum value for the wet season was in GLD and ABJ, while it was at TGM during the dry season. At GSA, concentration of NO_2 was significantly higher in concentration for both seasons than at other dumpsites. The mean values for NO_2 were higher than reported by both Ezekwe *et al*, (2016) and Nwakanma *et al*, (2016). This parameter showed least significant variation in the remaining dumpsites. The reddish-brown toxic gas is characteristic of a sharp, biting odour, toxic by inhalation and at low concentrations (4 ppm) the gas will anesthetize the nose, thus creating a potential for overexposure.

The mean concentration of SO_2 ranged between 0.1092 mg/m^3 to 1.8122 mg/m^3 in the wet season and 0.0000 mg/m^3 to 0.3639 mg/m^3 for the dry season. Uba, 2015 reported a range of 0.0011 ppm to 0.0390 ppm (0.0029 mg/m^3 to 0.1000 mg/m^3) for the wet season in Zaria. This toxic gas with a pungent, irritating and rotten smell is a major air pollutant and has significant impacts upon human health. Inhaling sulphur dioxide is associated with increased respiratory symptoms and disease, difficulty in breathing, and premature death. In addition, the concentration of sulphur dioxide in the atmosphere can influence the habitat suitability for plant communities as well as animal life. Sulphur dioxide emissions are a precursor to acid rain and atmospheric particulates.

Result indicates that the mean concentration value of CO ranged between 0.0862 mg/m^3 to 1.9005 mg/m^3 and 0.1114 mg/m^3 to 14.0638 mg/m^3 for the wet and dry seasons respectively. The values are a function of dumpsite fire both the wet and dry seasons. GSA, MPP, BWR, GLD and KUJ were observed to record

concentration values higher than NESREA guidelines in the wet season. Concentration values of CO in all the dumpsites excluding KWL exceeded NESREA guideline values during the dry season. It is important to note that even the closed dumpsites (AJT and MPP) are still contributing to pollutant emission in the study area. This result is similar in range to reports by Njoku, (2015) and Ubouh *et al*, (2016) while the mean values for the wet season are far lower than report by Rim-Rukeh, (2014). On the whole the level of uncontrolled burning was observed to be lesser in the wet season than in the dry.

Concentration of H_2S ranged from 0.0232 mg/m^3 to 0.4404 mg/m^3 during the wet season and 0.0232 mg/m^3 to 0.4065 mg/m^3 for the dry season. Pollutant emission level of H_2S exceeded NESREA tolerable limit at GSA, KSH, MPP, BWR, TGM, GLD and KUJ during the wet season, while concentration of H_2S was above permissible level at GSA, KSH, BWR and GLD during the dry season. This most common sulphides responsible for landfill odours was found to show significant variation at 95 confidence level at GSA, BWR, GLD and KUJ, however there is no significant variation amongst the other sites. Results are higher than report by Uba, 2015. The gas produces a very strong rotten-egg smell even at very low concentrations. It is the most emitted from landfills at the highest rates and concentrations.

Generally, concentration of CO_2 ranged between 1.7669 g/m^3 to 2.3802 g/m^{3}for wet season and 1.6365 g/m^3 to 1.9923 g/m^3, the concentration of CO_2 in the study area was relatively higher in the wet season than during the dry season. Analysis of the standard error mean of readings from all the dumpsites shows that the concentration level of CO_2 was significantly higher in variation at AJT dumpsite while there was no significant variation in the concentration level of CO_2 in other dumpsite locations in the study area at $p>0.05$. The values for CO_2 recorded from all the dumpsites exceeds that reported by Ezekwe *et al*, 2016.

Statistical Analysis

Analysis of variance (ANOVA) test was applied to test if there was any significant statistical difference between mean values of wet and dry seasons. F-value was 1.965175 while F-critical was 1.742273 at $\alpha < 0.01$. Therefore, we conclude that a significant difference existed between the air quality parameters measured in the wet and dry season in FCT.

Table 4: Correlation Matrix between Air Quality Parameters in the Wet Season for the Study Area

	CH_4	NO_2	SO_2	CO	H_2S	CO_2
CH_4	1					
NO_2	-.008	1				
SO_2	.117**	.070*	1			
CO	.079**	.099**	.176**	1		
H_2S	.098**	.075**	.014	.207**	1	
CO_2	.011	-.009	.109**	.003	-.003	1

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Table 5: Correlation Matrix between Air Quality Parameters in the Dry Season for the Study Area

	CH_4	NO_2	SO_2	CO	H_2S	CO_2
CH_4	1					
NO_2	.382**	1				
SO_2	.142	.557**	1			
CO	.621**	.454**	.299*	1		
H_2S	.707**	.393**	.388**	.445**	1	
CO_2	.504**	.024	.018	.206	.401**	1

** Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Tables 4 and 5 shows the correlation between air quality parameters during the wet and dry seasons respectively. Table 4, reveals the correlation between CH_4, and SO_2, CO, H_2S to be 0.117 ($p<0.01$), 0.079

($p<0.01$) and 0.098 ($p<0.01$) respectively, this implied that as concentration of CH_4 increased, there was increase in the mean concentration of SO_2, CO and H_2S at 99% CI. There was also a significant correlation between NO_2 and SO_2, CO, H_2S at 0.070 ($p<0.05$), 0.099 ($p<0.01$) and 0.075 ($p<0.01$), the correlation between NO_2 and SO_2 was at 95% CI, whereas that between NO_2 against CO and H_2S was at 99% CI., there was a correlation between CO and H_2S observed at 0.207 ($p<0.01$). The correlation between air quality parameters during the dry season as presented in Table 5, shows a significant correlation between CH_4 and NO_2, CO, H_2S and CO_2, at 0.382 ($p<0.01$), 0.621 ($p<0.01$), 0.707 ($p<0.01$) and 0.504 ($p<0.01$), CH_4 was observed to correlate positively with NO_2, CO, H_2S and CO_2 at 99% confidence interval respectively. Finally, there was a correlation between CO and H_2S at $r=0.445$ ($p=0.001$) and H_2S positively correlates with CO_2 at 0.401 ($p=0.01$).

Geo-statistical Analysis of Air Quality in the study Area.

Using Arc GIS 10.3, mean concentration emission of Air Quality parameters measured for the wet and dry seasons in the study area are presented on map in Figures 1 to 12 to show the extent of influence of dumpsites pollutant in the area. Emission level of CH_4 as seen in Figure 1, shows that the highest emission around GSA, a higher concentration at the central part of the study area (0.09 – 0.36 mg/m^3), the output grid for concentration of CH_4 reduces towards the southern part of the study area, some patches of low concentration around the north and north west section with concentration between (0.0 – 0.01 mg/m^3) while the moderate to high is between (0.03 -0.09 mg/m^3). The highest emission concentration output grid (0.038 – 0.115 mg/m^3) of CH_4 in Figure 2 was at the central part GSA, this waste dumpsite emits the highest concentration of CH_4 in the dry season. Similarly, the southern section of the study area reveals low concentration of the CH_4 between (0.00-0.01 mg/m3). This relatively lower concentration level follows the pattern of population distribution character of the study area. On the whole, CH_4 concentration is within the study area is within permissible limits of FEPA.

Emission level of NO_2 in the study area for wet season can be seen in Figure 3, there is an indication that higher concentration in the central part of the study area, the emission concentration output grid of NO_2 reduces towards the entire western section of the study area and some patches of low concentration around the north eastern section with concentration between (0.00 – 0.28 mg/m^3) while moderate around the south eastern section AJT and KSH between (0.28 – 0.62 mg/m^3). Figure 4 shows that there is a higher mean concentration emission (0.68 – 1.13 mg/m^3) of NO_2 in the dry season from the central to the eastern part of the study area GSA and AJT. Similar to the observed pattern during the wet season, the western and north eastern part of the study area recorded the lowest emission level (0.00-0.20 mg/m^3). Similarly, the south eastern section of the study area reveals moderately high concentration of the NO_2 between (0.34-0.50 mg/m^3). The waste dumpsites at GSA, AJT and TGM were most impactful in NO_2 emission in the study area while ABJ, KWL, GLD, BWR and MPP were less impactful as far as NO_2 is concerned.

Figure 5, displays the emission level of SO_2 in the study area for wet season, there was higher concentration from the central part of the study area, the emission output grid of SO_2 reduces towards the southern section of study area, with some patches of low concentration around the north and north western section, the concentration ranged between (0.02 – 0.43 mg/m^3) while moderate to high is between (0.43-1.19 mg/m^3). The most significant emission of the pollutant was observed around GSA and BWR. It can also be observed in Table 6, that there is higher (0.24 – 0.5 mg/m^3) concentration of SO_2 at the south eastern and south western section an indication that concentration of dumpsite emission gases in the area as related to uncontrolled burning of waste which was higher during the dry season, by implication this may result in health risk to the people within the area. Similarly, the northern and southern section of the map reveals low concentration of the SO_2 between (0.00-0.05 mg/m^3). This may be attributed to low population and little or no activities that lead to the release of the gas.

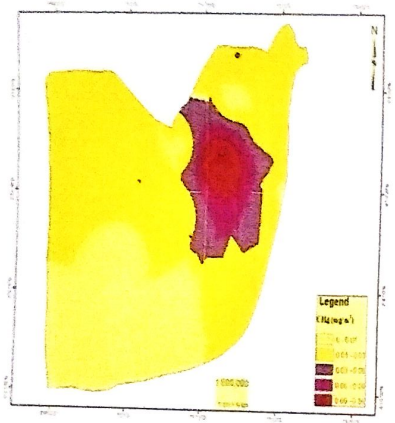

Figure 1: Emission of CH_4 for the Wet Season in the study area

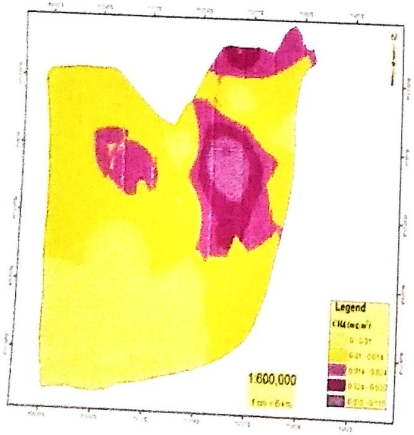

Figure 2: Emission of CH_4 in for the Dry Season in the study area

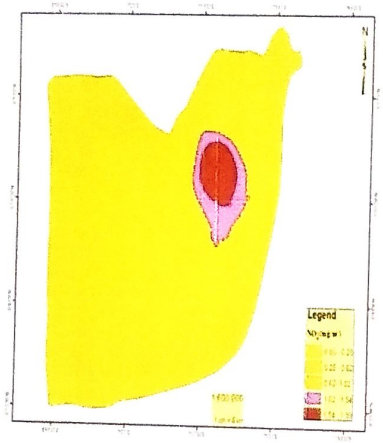

Figure 3: Emission of NO_2 in for the Wet Season in the study area

Figure 4: Emission of NO_2 in for the Dry Season in the study area

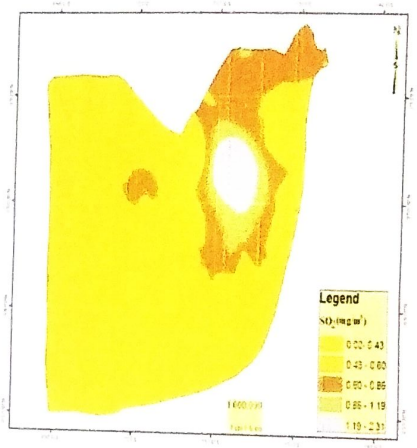

Figure 5: Emission of SO_2 in for the Wet Season in the study area

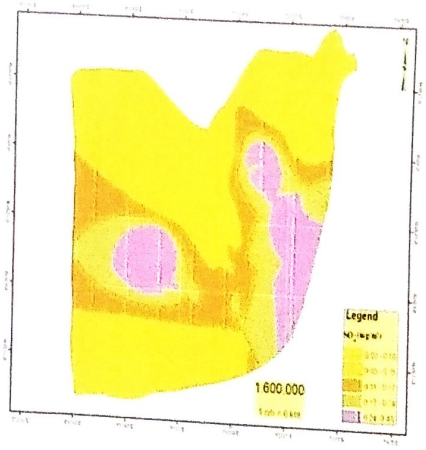

Figure 6: Emission of SO_2 in for the Dry Season in the study area

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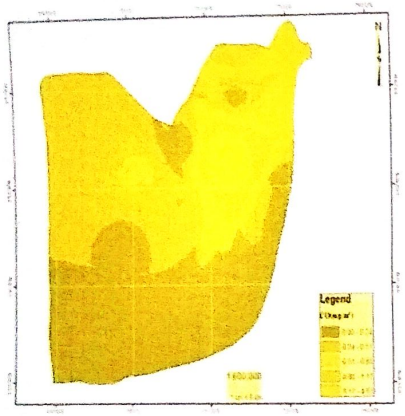

Figure 7: **Emission of CO in for the Wet Season *in* the study area**

Figure 9: Emission of H_2S in for the Wet Season in the study area

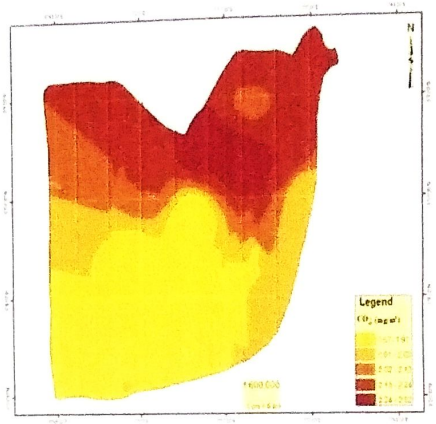

Figure 11: Emission of CO_2 in for the Wet Season in the study area

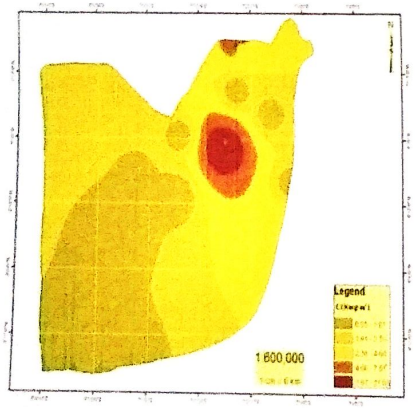

Figure 8: **Emission of CO in for the Dry Season *in* the study area**

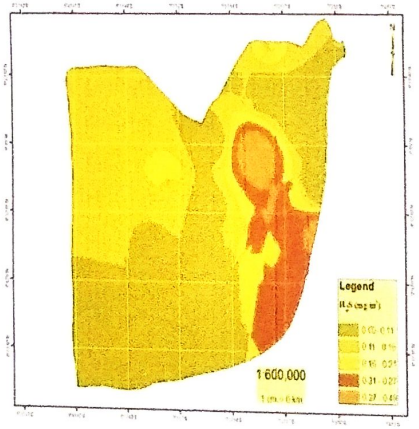

Figure 10: Emission of H_2S in for the Dry Season in the study area

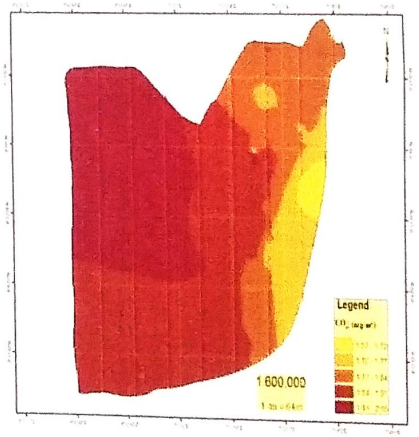

Figure 12: Emission of CO_2 in for the Dry Season in the study are

Figure 7, shows the emission concentration level of CO in the study area for wet season, the map indicates that there was higher concentration of the pollutant at the central and fringes of the north eastern part of the study area GSA and BWR (0.80 – 4.53 mg/m^3), the output grid of CO concentration reduces towards the southern section of the map and some patches of low concentration around the north and north west section with concentration between (0.00 – 0.51 mg/m^3). This is the pollution pattern is essentially due to uncontrolled burning of wastes and also the volume of wastes disposed in the dumpsites. It can also be observed in Table 8, that there is higher concentration at the central and fringes of the north eastern part of the study area GSA and BWR (4.66 – 21.05 mg/m^3) concentration of CO at the south western section an indication that those areas are less in emission concentration (0.05 – 1.61 mg/m^3) while concentration around the south eastern part of the study area ranged between (1.61 – 4.66 mg/m^3). CO concentration level in the dry season is elevated by level uncontrolled burning of waste which is usually escalated with the dry season when dump fire rages on for long unabated in various waste dumpsites

H_2S in the study area for wet season, it can be observed in Figure 9, the emission concentration level of was higher at the central and fringes of the north eastern part of the study area GSA, TGM and BWR (0.30 – 0.62 mg/m^3), the concentration output grid of H_2S reduces towards the southern and eastern section of the study area ABJ, KSH, AJT and DTS (0.00 – 0.18 mg/m^3), some patches of moderate concentration around the north and north east, western and central section with concentration between (0.18 – 0.24 mg/m^3). Figure 10, shows that a higher emission concentration from the central and eastern fringes of the study area GSA, AJT and KSH (0.21 – 0.49 mg/m^3), for H_2S, at the southern and north eastern sections, the lowest emission level of H_2S was recorded (0.00 – 0.11 mg/m^3) an indication that those areas are less in emission concentration. H_2S concentration level in the dry season is lower than the emission level during the wet season.

Emission concentration level of CO_2 in the study area for wet season can be seen in Figure 11, the indication that there was higher concentration at the central and northern part of the study area (2.13 – 2.53 g/m^3), the output grid of CO_2 concentration reduces towards the entire southern section of the study area showed the lowest concentration between (1.67 – 2.02 g/m^3) while the moderate around the north western section between (2.02 – 2.13 g/m^3). Figure 12, however show that the highest emission (1.84 – 2.05 g/m^3) concentration of CO_2 in the dry season from the central to the western and southern parts of the study area. The western part of the study area recorded the lowest emission level (1.57 – 1.70 g/m^3).

Conclusion and Recommendations

The concentration level of the evaluated gases in the dumpsites within the study area was found to vary over locations (spatially) and seasons (temporal). On the whole, concentration of most measured gases was higher at the dumpsites relative to the control points. Test of Correlation analysis reveal that most of the gas pollutants showed positive significant correlation at 95% and 99% confidence interval. F-value was greater than F-critical at $\alpha<0.01$, which indicated a significant difference in concentration of air quality parameters between the wet and dry seasons. SO_2, H_2S, CO_2 and CO were pollutants that exceeded FEPA and NESREA guidelines in most of the dumpsites for both seasons while CH_4 and NO_2 were within the threshold values. Method of waste disposal which is largely open dumping, the incidence of uncontrolled dumpsite fires are common occurrences within the study area. Apart from pollution from active dumpsites, it was observed that closed dumpsites were also responsible for pollution as post closure impact. Air pollution from the dumpsite in the study area could threaten the health of anyone especially the dump site workers that are regularly exposed to them. This study observed that exposure to chemicals and other substances emitted from dumpsite fires is high especially NO_2, SO_2, CO_2 and CO are likely to present a significant risk to human health.

Most of the dumpsites were observed to be an emission source of air pollutants of public health importance, it is therefore recommended that:

1. Environmental education about emission of air pollutants is required for dumpsite workers and nearby residents, so they can understand the effects of dumpsites on their health and neighbourhood.
2. Studies on the air quality variations with seasons over a longer period is required for better understanding of pattern and or trend as well as data source to curb greenhouse gases which can endanger sustainable development.
3. There is need for government to develop better practices for the waste disposal operation towards sustainable waste management practices such as introduction of engineered landfill sites and well as integrated solid waste management system to reduce or eradicate emission at dumpsites.
4. Remediation strategy to deal with post closure impact of dumpsites is necessary to mitigate continuing impact from closed dumpsites.

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