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Research Article

An Assessment of Gaseous Emission from Awotan Dumpsite in Ibadan, South Western Nigeria

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Summary: Gaseous emission, particulate emission, biological molecules and other harmful substances discharge into the atmosphere from dumpsite environment. The carbon dioxide (CO_2) and methane (CH_4) content of the gaseous emission from different platforms and offsets of the Awotan dump site were measured. P Sense CO_2 Meter AZ 7755 was used to measure the level of carbon dioxide gas, temperature and relative humidity. K60 Gas detector was used to measure the level of methane (CH4) gas and Pm 2.5. Thermo-scientific MIE pDR 1500 PM monitor was used to measure the particulate matter on the dumpsite. The CO_2 levels (697±28.84 - 502±2.19) were above the minimum permissible levels of ASHRAE of 400ppm for all platforms at the dumpsite. CH_4 levels range (73.33±3.32 – 18.33±4.27) was above the methane explosive limits (MEL) of 15% for all Platforms, however the level at 25m and 50m offsets (14.83±4.11 – 13.83±2.48) was below the MEL for 75m and 100m offsets. PM2.5 levels were lower in the morning and peaked in the afternoon at Platform 5, 6 and 9 locations with values of 62.76±6.03, 63.9±11.37 and 32.06±3.89 respectively which is not within the WHO minimum permissible limit of 25µg/m3. There was a significant positive correlation between CO2 and CH4 (r=0.7558, p=0.028) but no significant correlation between CO_2 and other meteorological parameters (temperature and humidity) (r=-0.1309, p=0.67and r=0.09644, p=0.754). The carbon dioxide and methane content of the gaseous emission from the Awotan dump site are potential health hazard, hence the need for an engineering design that will reduce the quantum of the emission thereby reducing the hazard.

Keywords*: Dumpsite, Gaseous pollutant, Particulate Matter, Air Quality, Awotan, Ibadan*

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INTRODUCTION

Solid waste and poor management in dumpsite increase the amount of gaseous emission, particulate emission, biological molecules and other harmful substances into the atmosphere (Boardi *et al* 2005, Babs-Shomoye and Kabir 2016). The pollutants so introduced into the atmosphere can have severe effect on humans and the ecosystem in general (Nwafor *et al* 2019). According to United States Environmental Protection Agency USEPA (2012), criteria pollutants are commonly found air pollutants which could have severe health and environmental implications. These pollutants include; particulate matter (PM_{10}), carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), methane (CH_4), ammonia (NH_3) and hydrogen sulphide (H_2S) (Jha *et al* 2008, Olla *et al* 2015). The gaseous pollutants are colourless and invisible while the particulate matter such as dust and soot are not. Although, pollutants are naturally present in air, human activities such bush burning, industrial processes, decaying of accumulated organisms and domestic wastes increase their atmospheric concentration (Dare 2000, Oladejo and Otene 2018). The quality of the ambient air in any environment is determined by the extent and severity of pollution (Ubuoh and Akhionbare (2011), Agwu and Ozeh (2013) thus air pollution is spatial-temporal. Globally, most municipal wastes are dumped in non-regulated landfills which generate landfill gas (LFG) as a by-product (Johnson 2010).

The impact of these wastes affects health and livelihood of people (Boardi *et al* 2005, Salam 2010, Babs-Shomoye and Kabir 2016). LFG is generated when organic material decomposes anaerobically, consisting of methane (45- 60%), carbon dioxide (40-60 %) and other gases (2-9%) which are mostly emitted to the atmosphere (Metz *et al*. 2007, Jha *et al* 2008). According to the International Panel on Climate Change, methane emission from landfills account for 3-19% of the anthropogenic sources in the world and is considered as a large contributor to global warming after agricultural activity and losses from fossil fuel distribution (IPCC 1996; Metz *et al*. 2007; Johnsson 2010). The impact of dumpsite solid waste was equally assessed on drinking water sources (Sia Su 2007).

Awotan dumpsite situated in Ido Local Government Area of Oyo State, Nigeria has being in use since 1997 and has adjoining residential and commercial buildings within 300 metre radius. In this study, an assessment of emitted gases from the Awotan dumpsite was carried out with a view to assessing its environmental and health impact on people living in the area.

MATERIALS AND METHODS

Ethical Approval: All applicable international, national, and institutional guidelines for environmental assessment were followed.

Study Area: The study was carried out at Awotan Dumpsite in Ibadan (Latitude 7°27'45.67''N and Longitude 3°50'59.15''E), Nigeria. Awotan dumpsite is located in Ido local Government Area which is a rapidly developing settlement area of more than 2 million populace in Oyo state, Nigeria. The dumpsite has a size of approximately 20.59 hectares and divided into 9 platforms. The fresh waste dumps (yellow areas) were platforms 2,5 and 6 while 1,3,4,7,8 and 9 were old waste dumps (red areas)-Plate 1. The main criterion for the selection of Awotan dump site amongst others was the high carbon and nitrogen content of the waste (Tables 1& 2).

Platforms: Nine (9) Platforms and 4 Offsets on the dumpsite environment served as the sampling locations (SL) of this study. Platform 5, 6 and 9 are of old dumps, new dumps and scavengers gathering respectively and other platforms were abandoned landfills as at the time of this study. 100m offset serves as residential area close to the dumpsite, 75m offset is the access road linking the dumpsite environment and street and other offsets are distances measured at 25m interval as shown in Table 3.

Table 1:
Composition of MSW from the three Dump Sites in Ibadan.

Composition	Percentage contribution		
	Awotan	Ajakanga	Afofunra (Aba Eku)
Paper & Textile	21.99	23.14	19.46
Garden, Park or non food waste	15.64	26.65	25.47
Food waste	36.67	21.80	26.51
Wood/Straw	25.70	28.40	28.57
Total	100	99.99	100

Source: Centre for People and Environment (CPE) for Methane-To-Markets Program USEPA on Landfill Recovery and Use in Nigeria, 2010

Levels of landfill gases comprising carbon dioxide (CO_2) and methane (CH_4) were determined using P-Sense plus CO_2 meter AZ-7755 and K-60 gas detector respectively. The measurements were taken thrice weekly at each location for the entire six week duration of the study. Measurements were carried out at nine platforms (PL1- PL9) and at four offsets from the dumpsite area (25m, 50m, 75m, and100m) and the means of the readings were computed.

The gas monitors were calibrated on the field in a Ziploc-polythene bag which was free of the target gas. The gas monitors were hand held at the sampling locations and stretched at arm's length to determine the ambient levels of the pollutants. The levels of particulate matter at all the study locations were determined by means of $Pm_{2.5}$ and readings recorded morning and evening device. The device was placed on a stable platform and switched on at a height of 1.5m. The measurement was recorded when the readings on the display screen were stable.

Statistics:
Quantitative data were expressed as means ± standard deviation. Two-tailed student t test was used for data comparison and a confidence level of 95% with $P \leq 0.05$ to determine significance. Pearson correlation was used to test the relationship between CO_2 and CH_4 as well as CO_2 and meteorological parameters (temperature and humidity).

Table 2:
Ultimate analysis of the combustible components of Ibadan MSW

Component	Carbon %	Hydrogen %	Oxygen %	Nitrogen %	Sulphur %	Ash %
Food Waste	51.85	3.79	40.23	2.39	1.24	9.75
Paper & Cardboard	56.34	6.13	36.59	0.34	0.21	4.38
Plastic	64.28	6.89	27.44	0.96	0.39	3.04
Textile	53.26	5.76	40.07	0.69	0.18	2.43
Rubber	51.28	5.96	36.22	0.24	0.12	6.13
Wood	46.24	6.08	44.42	0.17	0.03	2.97
Miscellaneous (Dirts,Ashes, etc.)	59.78	2.76	41.79	0.42	0.25	3.79

(Source: Methane Generation Potential of Municipal Solid Waste in Ibadan, 2014)

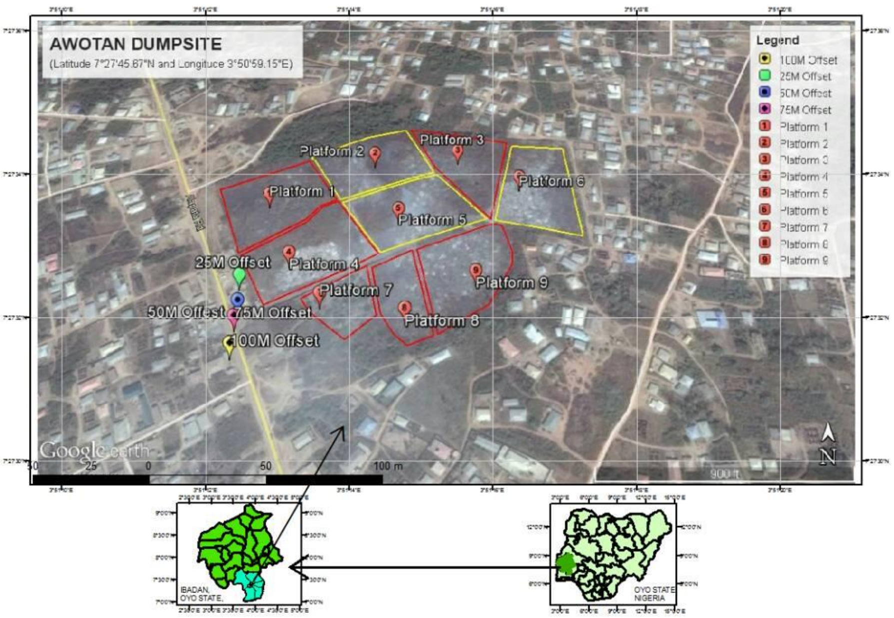

Plate 1:
Location Map of Awotan dumpsite (Source: Arc GIS and Google Map)

Table 3:
Coordinate and Elevation of Sampling Points at Awotan dumpsite

Sampling Point	Longitude	Latitude	Elevation
PL 1	7^{0}27'46.93"N	3^{0}50'53.52"E	730ft
PL 2	7^{0}27'49.07"N	3^{0}50'57.95"E	765ft
PL3	7^{0}27'49.00"N	3^{0}51'02.26"E	769ft
PL 4	7^{0}27'44.17"N	3^{0}50'54.91"E	730ft
PL 5	7^{0}21'46.37"N	3^{0}50'59.59"E	767ft
PL 6	7^{0}21'47.65"N	3^{0}51'05.15"E	752ft
PL 7	7^{0}21'41.79"N	3^{0}50'57.17"E	740ft
PL 8	7^{0}21'42.73"N	3^{0}50'59.37"E	752ft
PL 9	7^{0}27'43.70"N	3^{0}51'01.64"E	756ft
25m offset	7^{0}27'47.77"N	3^{0}50'52.28"E	715ft
50m offset	7^{0}27'42.72"N	3^{0}50'52.85"E	712ft
75m offset	7^{0}27'41.54"N	3^{0}50'52.28"E	708ft
100m offset	7^{0}27'41.30"N	3^{0}50'51.92"E	706ft

RESULTS

The mean carbon dioxide concentrations from all the sampled areas of the dump site significantly exceeded the minimum permitted limit level as prescribed by the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) (Table 4).
The mean methane concentrations for the sampled areas apart from offsets 75m and 100 m were significantly higher than methane explosive limit (Table 4).

The moisture content of the organic fraction of the waste being 44.6% could contribute to the high heating value of the municipal waste. The 28.7% moisture content of the MSW might be responsible for the offensive odor being emitted from the dumpsite.

The mean levels of particulate matter were low in the morning but high in the afternoon especially at platform 5,6 and 9 that had regular dumping and frequent burning of wastes. Platform 5, 6 and 9 had respective afternoon levels of 62.76±6.03, 63.9±11.37 and 32.06±3.89 µg/m^3 that were significantly higher than the WHO minimum permissible level of25 µg/m^3 (Figure 4).

Pearson correlation test was carried out between CO_2, CH_4 and the meteorological parameters as shown. The table shows that there was a significant positive correlation between CO_2 and CH_4 ($r=0.7558$, $p=0.0028$) and no significant correlation between CO_2 and other meteorological parameter ($r=-0.1309$, $p=0.67$) for Co_2 and Temperature likewise ($r=0.09644$, $p=0.754$) for CO_2 and Humidity

Table 4:
Air Quality Assessment for CO_2, CH_4, $PM_{2.5}$ and Meteorological parameters

S/N	Platforms /Offsets	Mean	Ashrae Mpl	Mean	Mel	Morning Readings	Afternoon Readings	Who Mpl
		ACR (PPM)	**ACR (PPM)**	**AMR (%)**	**AMR (%)**	**Pm2.5 (μg/m³)**	**Pm2.5 (μg/m³)**	**Pm2.5 (μg/m³)**
1	Platform 1	565.5±24.41*	400	66.333±2.50*	15	0±0	1.36±2.36	25
2	Platform 2	579.333±6.65*	400	62.333±1.50*	15	4.33±1.65	19.63±5.64	25
3	Platform 3	642.166±22.92*	400	67.5±4.88*	15	0±0	9.53±0.40	25
4	Platform 4	563.333±55.05*	400	64.333±2.33*	15	9.0±1.90	19.76±3.65	25
5	Platform 5	587±8.17*	400	67.667±2.80*	15	10.83±1.56	62.76±6.03*	25
6	Platform 6	697±28.84*	400	73.333±3.32*	15	7.43±2.67	63.9±11.37*	25
7	Platform 7	530±22.93*	400	52.667±1.96*	15	5.2±1.47	25.9±4.40	25
8	Platform 8	515.5±3.88*	400	53.667±2.73*	15	0±0	1.96±1.56	25
9	Platform 9	512.666±5.78*	400	52.833±2.99*	15	3.9±2.21	32.06±3.87*	25
10	25m offset	504.5±2.88*	400	20.167±5.07*	15	5.8±2.47	7.63±2.40	25
11	50m offset	504.833±1.47*	400	18.333±4.27*	15	6.33±3.75	8.66±4.25	25
12	75m offset	503.333±3.72*	400	14.833±4.11	15	5.2±1.47	13.83±3.06	25
13	100m offset	502±2.19*	400	13.833±2.48	15	1.9±1.68	2.86±1.22	25

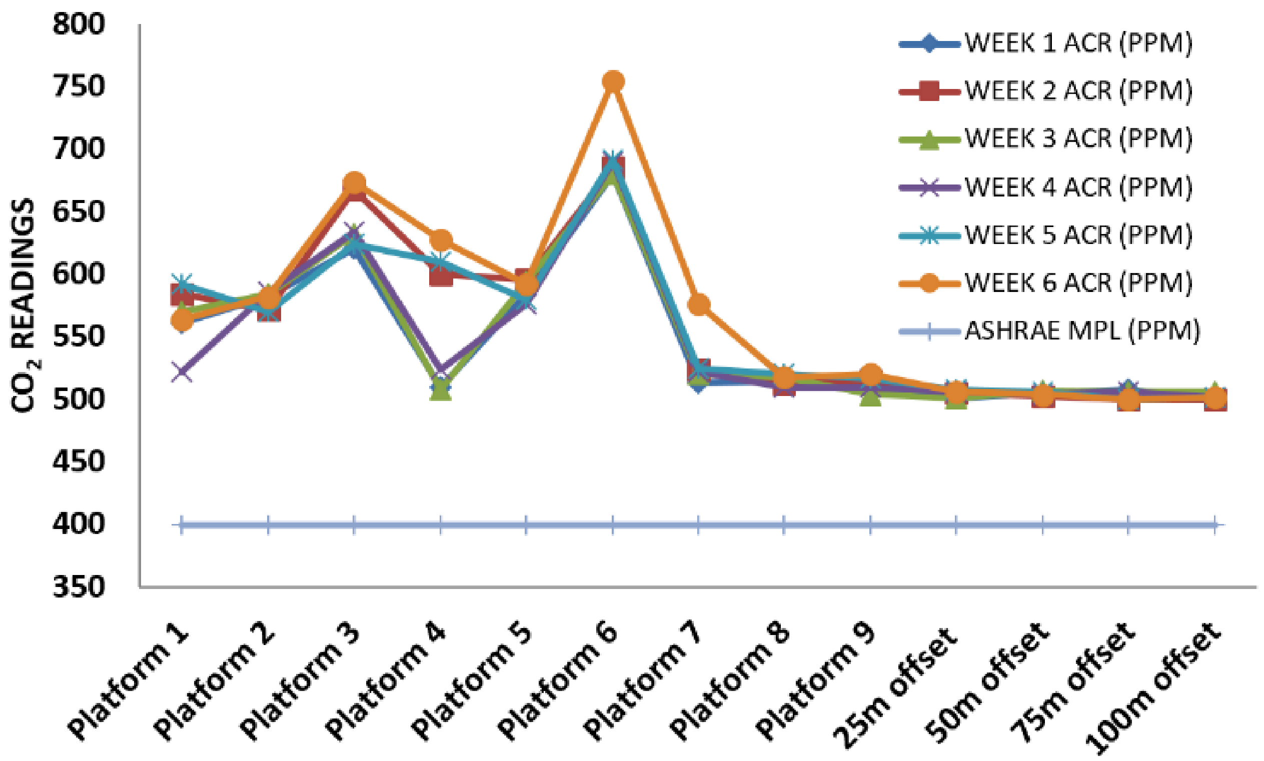

Figure 2:
CO2 Concentrations at sampling locations

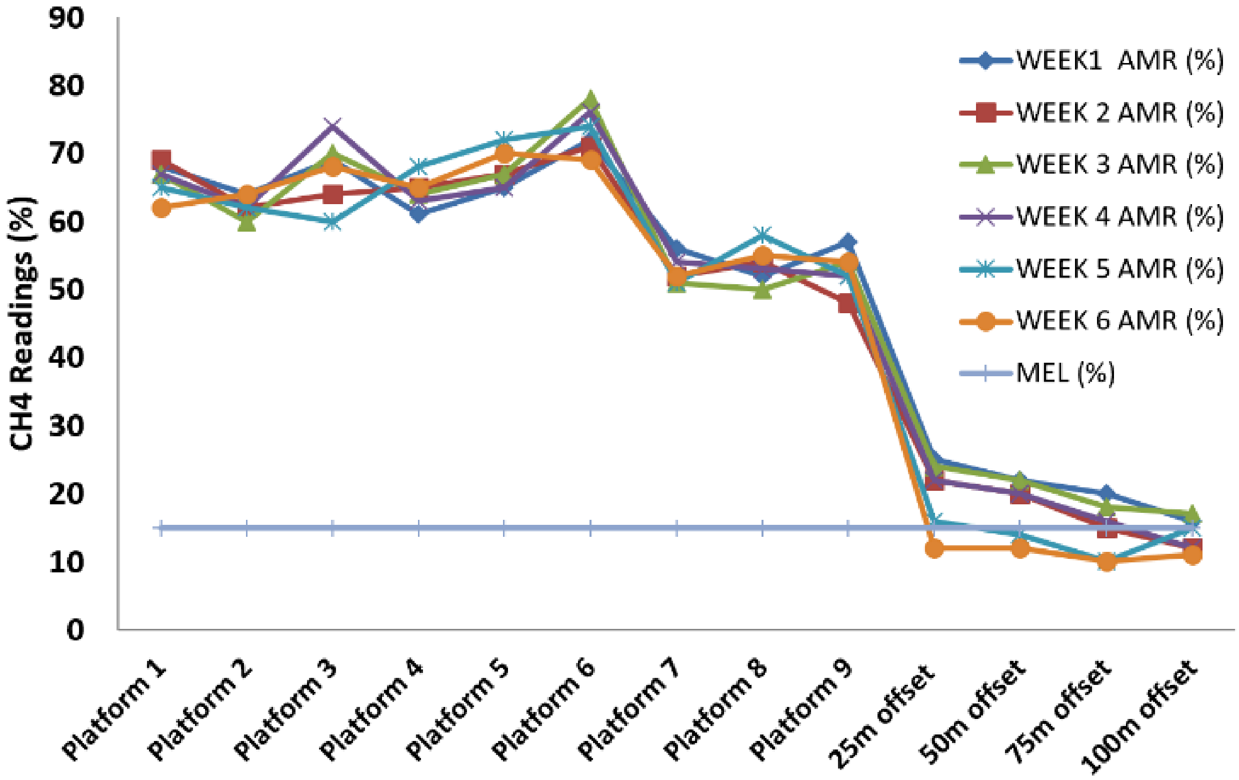

Figure 3:
CH_4 Concentrations at sampling locations

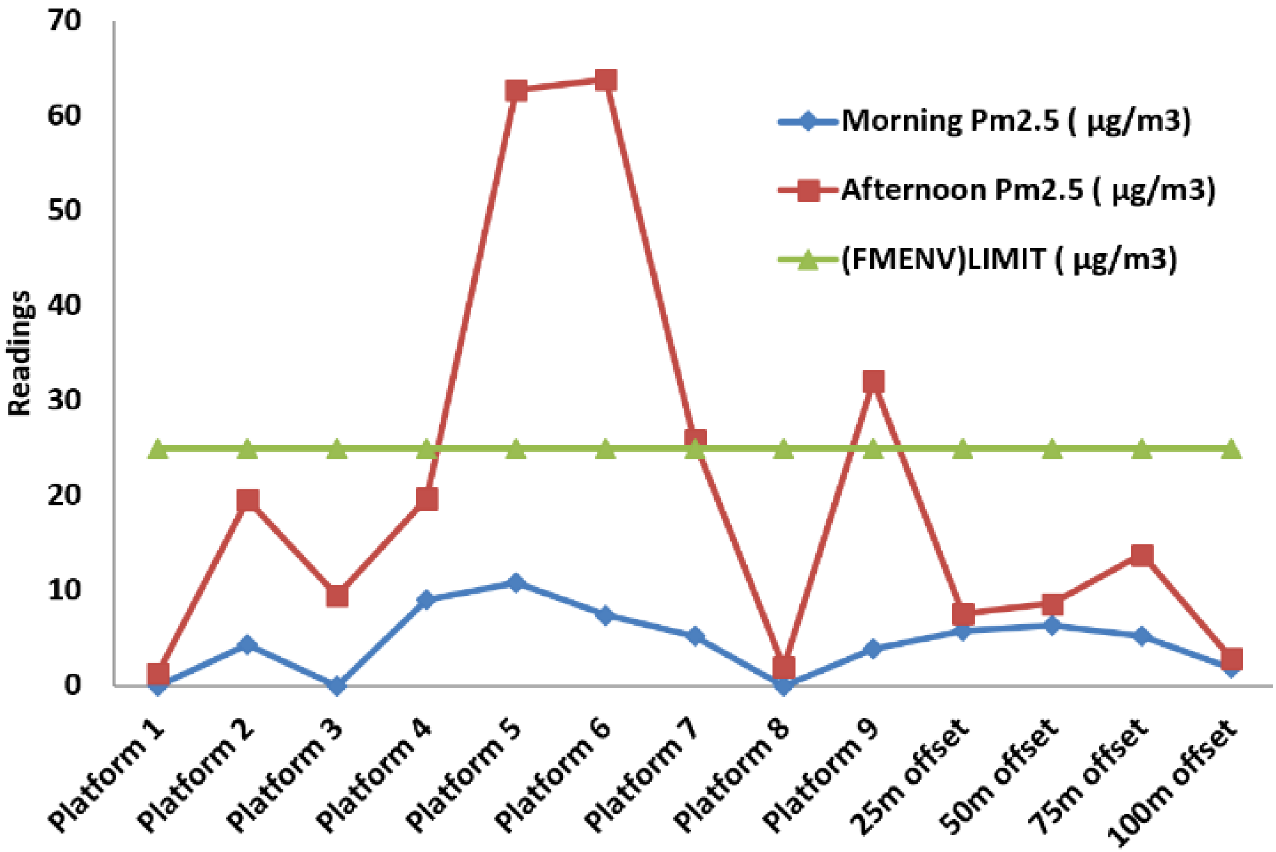

Figure 4:
Concentrations at sampling locations

DISCUSSION

This study investigates the impact of municipal wastes on air quality, recording the variation of pollutants from different platforms and offsets in the dumpsite environment. Both carbon dioxide and methane concentrations were significantly higher than the WHO minimum permissible limits in the Awotan dumpsite. These were likely be consequent upon activities at the dumpsite which included but not limited to anaerobic and aerobic decomposition of organic and biodegradable wastes, burning of combustible wastes such as papers, wooden, plastics and rubbers. Asides from the health hazard which these gases constitute, they also cause increased environmental temperature leading to global warming (Jha *et al*, 2008). This has diverse effects on human population activities such as agriculture, aquaculture and animal husbandry (Salam 2010).

More so, the site has become popular with dump activities. Human settlement and population have really increased in the vicinity which was not hitherto. And the regular visit of humans to the dumpsite to scavenge for renewable waste on the site makes this study paramount for human and animal wellbeing. The moisture content from the waste could be responsible for the high heating value of the municipal solid waste which generates the offensive odor on and around the dumpsite, corroborated by findings of Sia Su (2007) in Payatas dumpsite in Quezon City, Philippines. The diurnal variation of the particulate matter content of the air was a reflection of the offensive odour and amount of humidity on the dumpsite (Boardi *et al* 2005).

These findings corroborated the reports of Akintayo and Olonisakin (2014) which found the typical compositions of the municipal solid waste to comprise over 30% organics, 20% paper and cardboard; tin cans constitute 9%; ashes and other constituents of the waste account for 6%. Similar composition was reported in Payatas dumpsite (Sia Su, 2007) and in Accra metropolitan area (Boardi *et al* 2005), and in Indian cities (Sharma and Jain 2019).

The runoffs and leachates being generated by solid waste have been documented to affect ground water quality (Oyelami *et al* 2013) and to have induced lesions in laboratory animals (Balogun *et al* 2017). Considering the fact that human habitation and activites occur within 300 metres radius of Awotan dumpsite, the ground water might become polluted with disease causing organisms such as viruses, bacteria, fungi and parasites (Adesewa and Morenikeji 2017). This might lead to an outbreak of water borne diseases that might assume epidemic magnitude (Badmus *et al* 2014, Oladejo and Otene 2018). Thus there is a need for re-engineering design of the dumpsite in order to minimize its environmental hazard thereby reducing the human health implication In conclusion, it is obvious that municipal waste management in Awotan dumpsite needs to be improved to international standards of operations, as non-compliance will lead to the generation of smokes, unpleasant odor and general environmental degradation.

New settlement has sprung up in Awotan area very close to the dumpsite and the residents are liable for the negative effects of mismanagement on the dumpsite. To prevent the hazard that may be caused from this mismanagement, pragmatic design and proper management should be done on landfills. Further studies are recommended to investigate the safe offsets from Awotan dumpsite where individuals can reside and they will not be affected by the gaseous emission and particulate matter emission from the dumpsite.

REFERENCES

Adesewa A., Morenikeji O. (2017): Helminths and heavy metals in soils from a dumpsite in Ibadan city, Nigeria. Journal of preventive medicine and hygiene, 58(4), E328–E333.

Agwu A., Ozeh R.N. (2013): Evolution of Ambient Air Quality of Aba Metropolis, Nigeria. International Journal of Current Research, 5(4), 843-844.

Akintayo F.O., Olonisakin O.A., (2014): Methane Generation Potential of Municipal Solid waste in Ibadan. Nigerian Journal of Technology, 33(1), 49-53.

ASHRAE, 2004. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.1791 Tullie Circle NE Atlanta, GA 30329. ISSN 1041-2336. www.ashrae.org

Babs-Shomoye F., Kabir R (2016): Health Effects of Solid Waste Disposal at a Dumpsite on the Surrounding Human Settlements. J Public Health Dev Ctries. 2(3),268-275

Badmus B.S., Ozebo V.C., Idowu O.A., Ganiyu S.A., Olurin O.T. (2014): Physico-chemical Properties of Soil Samples and Dumpsite Environmental Impact on Groundwater Quality in South Western Nigeria. The African Review of Physics. 9(0015),103-113

Balogun T., Morenikeji O., Emikpe B., Oyelow O., Oyebanji V. (2017). Clinicopathological features observed in rats exposed to leachates from a municipal dump site in Nigeria. Zoology and Ecology, 28(1), 50-55

Boadi K.O., Kuitunen M. (2005): Environmental and health impacts of household solid waste handling and disposal practices in third world cities: the case of the Accra Metropolitan Area, Ghana. J Environ Health. 68(4), 32-36.

Centre for People and Environment (CPE) for Methane-To-Markets Program U.S. Environmental Protection Agency, USA. 2010. Landfill Recovery and Use in Nigeria (Pre Feasibility Studies of using LFGE). 2010. Centre for Research Training and Development UK (www.eajournals.org)

Dare S.S. (2000). Environmental Chemistry and Pollution Control. New Delhi: S. Chad Co. Ltd.

Hassan S.M., Abdullahi M.E. (2012). Evaluation of pollutants in Ambient Air: A case study of Abuja, Nigeria. International Journal of scientist and Research publications 2(12), 1-5

IPCC 1996. International Panel on Climate Change; Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Task Force on National Greenhouse Gas Inventories, Hayama, Japan, http://www.ipcc-nggip.iges.or.jp / public /gl/invs6.html.

Jha A.K., Sharma C., Singh N., Ramesh R., Purvaja R., Gupta P.K. (2008): Greenhouse gas emissions from municipal solid waste management in Indian mega-cities: A case study of Chennai landfill sites. Chemosphere 71, 750–758

Johnsson E., (2010): Correlation between Methane-concentration and emission from old Landfills in Sweden Master thesis Environmental Engineering submitted to the Department of Water Resource Engineering, Lund University. 71p.

Metz B., Davidson O.R., Bosch P.R., Dave R., Meyer L.A. (2007): Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007.Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Nwafor P.C., Odukanmi A.O., Salami A.T., Owonikoko M., Olaleye S.B. (2019): Evaluation of a Cement Dust Generation and Exposure Chamber for Rodents: Blood Heavy Metal Status, Haematological Variables and Gastrointestinal Motility in Rats. African Journal of Biomedical Research, 22(1), 79 - 87.

Oladejo O.A., Otene I.J.J. (2018): Environmental Hazards of Dumpsites in Ibadan, Nigeria. ASJ: International Journal of Health, Safety and Environments (IJHSE) 4 (03): 257-268

Olla TA, Akinlalu AA, Olayanju GM, Adelusi AO, Adiat KO (2015): Geophysical and Hydrochemical Investigation of a Municipal Dumpsite in Ibadan, Southwest Nigeria. Journal of Environment and Earth Science 5 (14), 99-112

Oyelami A.C., Ojo A.O., Aladejana J.A., Agbede O.O. (2013): Assessing the Effect of a Dumpsite on Groundwater Quality: A Case Study of Aduramigba Estate within Osogbo Metropolis. Journal of Environment and Earth Science 3(1):120-130

Salam A. (2010): Environmental and Health Impact of Solid Waste Disposal a Mangwaneni: Dumpsite in Manzini: Swaziland. Journal of Sustainable Development in Africa, 12(7):64-7.

Sharma K.D., Jain S (2019): Overview of Municipal Solid Waste Generation, Composition, and Management in India. J. Environ. Eng., 145(3), 04018143

Sia Su G.L.S. (2007): Impact on drinking water sources in close proximity to the Payatas dumpsite, Philippines. Journal of public health, 15 (1), 51-55

Ubuoh E.A., Akhionbare S.M.O. (2011). Effects of Pig Production on Ambient Air Quality of Egbeada in Mbaitoli Local Government area of Imo State, Nigeria. Journal of Sciences and Multidisciplinary Research (JSMR), 3, 8-16.

USEPA, 2010. Landfill Gas Energy Project Development Handbook, Prepared by the Landfill Methane Outreach Program, 9/8/10

USEPA, 2012. National Ambient Air Quality Standards. Retrieved on 31st may, 2014 from www.epa.gov/ air criteria.html.

WHO, 2006. WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Global update 2005 Summary of risk assessment. WHO/SDE/PHE/OEH/06.02.