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# Air Quality Assessment of Solid Waste Dumps in Residential Neighbourhoods of Makurdi Town

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The environs of urban centres in most developing countries are facing a serious depreciation in terms of quality of life caused by inadequate or poor solid waste management systems. Municipal solid waste management has been a challenging task for many cities. This study, therefore, assesses the effect of disposed neighbourhood solid waste on the air quality in Makurdi town. MSA Altair 5X Multi-gas Detector manufactured by Mine Safety Appliance Company USA was employed to measure the concentration of ambient air in the dumpsite's environment in the neighbourhoods. The ambient air quality measured were compared with regulatory standards of the Federal Environmental Protection Agency for Environmental Pollution Control in Nigeria which stipulated emission limits of pollutants from stationary sources such as from a site, process, stack and vent. Findings reveal poor ambient air quality in waste dumps due to the presence of concentrations of potentially harmful pollutants around solid waste dumpsites in Wadata and North Bank areas among the five selected neighbourhoods. The result shows the mean concentration of carbon monoxide (CO) gas (16.0ppm), $H_2S$ (M =10.51ppm), and $CH_4$ (M = 12.17ppm) recorded in Wadata, and North Bank: CO (M=12.16ppm), $H_2S$ (M = 4.17ppm), and $CH_4$ (M = 4.16ppm) recorded were above the regulatory standards recommended.

**Keywords**: Air quality; solid waste management; Quality of life; Pollution

## INTRODUCTION

Globally, the effective management of urban solid waste has been a challenging task among developing countries, and in Africa where there are significant difficulties in urban solid waste collection and disposal (Maria, Gois & Leitao, 2019). The environs of urban centres in most developing countries are facing a serious depreciation in terms of quality of life caused by inadequate or poor solid waste management systems (Chen, 2018). The dearth of quality urban waste management framework and practices irregularities at the local level are the identifiable significant factors (Verma, Kaur & Tripathi, 2020).

The all-inclusive eco-friendly urban waste management system has become a global challenge due to rapid urbanisation, population increase, limited resources, growing industrialization and changes in the standard of living in urban centres (Ramachandra *et al.*, 2018). Rapid population explosion and urbanization has worsened the urban condition by producing a massive amount of solid waste at a rate that exceedingly surpassing that of urban growth (Ying-Chu, 2018). It is reported that two billion tons of generated municipal solid waste were recorded in 2011 worldwide (Amoo & Faglenle, 2013), and by 2050 it's projected to exceed 9.5 billion tons (Chen and Lo, (2015). The tremendous increase in the volumes of municipal solid waste led to mismanagement by local authorities (Verma, Kaur & Tripathi, 2020). Raised in the living standard of the urban inhabitants has changed the pattern of goods consumed, which is directly proportional to the volume of solid waste generation (Chen, 2018; Verma *et al.*, 2020). Municipal solid waste generated encompasses all mixed wastes from urban, peri-urban regions, and the waste consists of waste discarded predominantly of household wastes with a minor portion of commercial, institutions, and industrial wastes (Chen, 2018).

Solid waste generation is an incessantly growing issue at the local scale and a challenging task for many cities. Studies revealed that the solid waste disposed is a source of greenhouse gases in an urban area. The municipal solid waste sector contributes 4% of the global total greenhouse gas emission (Metz, 2015). Greenhouse gases include carbon dioxide ($CO_2$), methane ($CH_4$), and volatile organic compounds (VOCs) etc. According to Stocker (2014), methane has a greater potent for global warming potential than carbon dioxide ($CO_2$) among all the greenhouse gases, and also, increase annual atmospheric concentration by 2% (Chen, 2018). In all the anthropogenic sources for the greenhouse gases, methane emission from landfill accounted for 3–9% in the world (Du et al., 2017). Furthermore, the United Nation Framework Convention on Climate Change (UNFCCC), the Paris Agreement (PA2105) signed by all 197 members in 2018 target to reduce global warming by holding the increase in global average temperature to below 2$^{o}$ Celsius by effectively control the emission of greenhouse gases into the atmosphere (European Commission, 2019).

Nigeria has witness growth in population and economic development occasioned by mineral resources exploration and exploitation. As a result, cities are expanding in size and the populations accompanied by an increase in waste generation on a weekly or daily basis (Eche *et al.,* 2015). Rapid urbanization with the increasing urban population, changing lifestyle of the people and as well as an increase rate of development has led to a proliferation in the generation of solid waste in Makurdi town (Aguoru, 2015). Makurdi urban area is rapidly urbanizing and fast become characterized by indiscriminate refuse disposal, an uncleared heap of refuse that threatens the health of the residents (Eche *et al.,* 2015). This study, therefore, assesses the effect of disposed neighbourhood solid waste on the air quality in Makurdi town.

## LITERATURE REVIEW

### *Municipal Solid Waste and Greenhouse Gas Emission*

Greenhouse (GHG) gas are atmospheric gases such as water vapour, carbon dioxide, methane, and nitrous oxide that aid the absorptions and emissions of radiation within the thermal infrared range. Greenhouse gases, shield the earth surface from heat (LeTreut *et al*., 2007). A naturally occurring shield of greenhouse gases comprising 1-2 percent of the earth's atmosphere, helps to absorbs the radiated solar energy from the space and minimise the heat impact on the earth to a comfortable and liveable range (LeTreut *et al*., 2007).

Human activities over the years have produced 40% increase in the atmospheric carbon emission concentration (Chen *et al*., 2018), and has further increased despite the large uptake by various natural sinks. Anthropogenic carbon dioxide ($CO_2$) emissions source in the atmosphere includes fossil fuel combustion, natural gas, soil erosion, deforestation, wastes and livestock agriculture (Mora, 2013). A continuous increased in the emission of greenhouse gas on earth surface at the present rate may explicitly imply increased in earth temperature, with possibly harmful effects on environments, biodiversity and the livelihoods of people globally (Mora, 2013). The most abundant greenhouse gases in the earth's atmosphere are - Ammonia ($NH_3$), Carbon dioxide ($CO_2$), Methane ($CH_4$), Nitrogen dioxide ($NO_2$), Sulphur dioxide ($SO_2$), Carbon monoxide (CO), Hydrogen sulphide ($H_2S$) and Particulate matter.

Diverse wastes and management options have different implications for energy consumption, methane emissions, and carbon sequestration. The municipal landfills air pollutants emitted contributes to the greenhouse gases emission in the atmosphere which causes severe harms to human health (Lazaridis & Chalvatzaki, 2010). Niloufer, Swamy, and Syamala (2014) assessed ambient air quality in solid waste dumpsites at Vijayawada, and Andhra Pradesh in India for possible health impacts using the handheld multi-gas analyser, Model-VEP-200 monitor found the presence of Methane ($CH_4$) and $NO_2$ gases which is within the allowable limits.

Weli and Adekunle (2014), examined the air quality in Rumuolumeni neighbourhood landfill in Port Harcourt to determining the possible influence of weather parameters on the concentration of air contaminants from the landfill. Air quality parameters examined from the study include nitrogen oxide, sulphur dioxide, methane, volatile organic compounds, ammonia ($NH_3$), and hydrogen sulphide ($H_2S$). The result reveals higher concentration of $CH_4$ (0.06 mg/m$^3$), $SO_2$ (0.67 mg/m$^3$), VOC (2.28mg/m$^3$), $H_2S$ (0.19 mg/m$^3$), and $NH_3$ (0.12 mg/m$^3$) except $NO_2$ at the dumpsite. Result reveal that relative dampness and temperature sways the concentrations of $NO_2$, $NH_3$ and $H_2S$. Similarly, Rim-Rukeh (2014) assessed the effect of municipal solid waste dump sites fire on atmospheric pollution in five (5) dump sites using hand-held air quality monitoring equipment. The results revealed a very high concentration of SPM (773 - 801 µg/m$^3$), CO (133.7 -141.6ppm), $CO_2$ (401 - 404.5 ppm), $NO_2$ (21.0 - 27.3 ppm), $SO_2$ (27.7 - 37.1 ppm), $NH_3$ (14.7 - 19.5 ppm), Methane (2310 - 2771 ppm), and $H_2S$ concentration (3.4 to 7.7 ppm) within the area of the dump site. Ubouh and Nwawuike (2016), evaluate the on-site and off-site ambient air quality at Nekede dumpsite in Owerri at a distance of 300 meters using the Crowcon Portable Gas Analyzer. The result confirms a high concentration of $CH_4$, $NH_3$, $NO_2$, $SO_2$ and Particulate Matter from the waste dumpsite except CO.

## METHODOLOGY

### *Study Area*

Makurdi is the administrative capital of Benue State, located on Latitude 7° 45' 50" N and Longitude 8° 32' 10" E, on the Benue River in the Niger-Benue trough (Figures 1). Makurdi urban area covers a landmass of approximately 16km$^2$ with a population of about 393,425 people (National Population Commission projected population 2020). Makurdi is growing at a rapid rate with the presence of the Federal institutions including Federal University of Agriculture, 72 Special Airborne Battalion Barrack, NASME Barrack, Nigerian Air Force Base, the Nigerian Navy Provost School and Benue State University, has been a pull force to its rapid urbanization in the town. The predominant occupation of the indigenous people is agriculture which ranges from crop cultivation at subsistence and commercial scales, fishing which takes advantage of the location of the Benue River, and small-scale animal husbandry, with others ranging from white collar-jobs to handcrafts and trading.

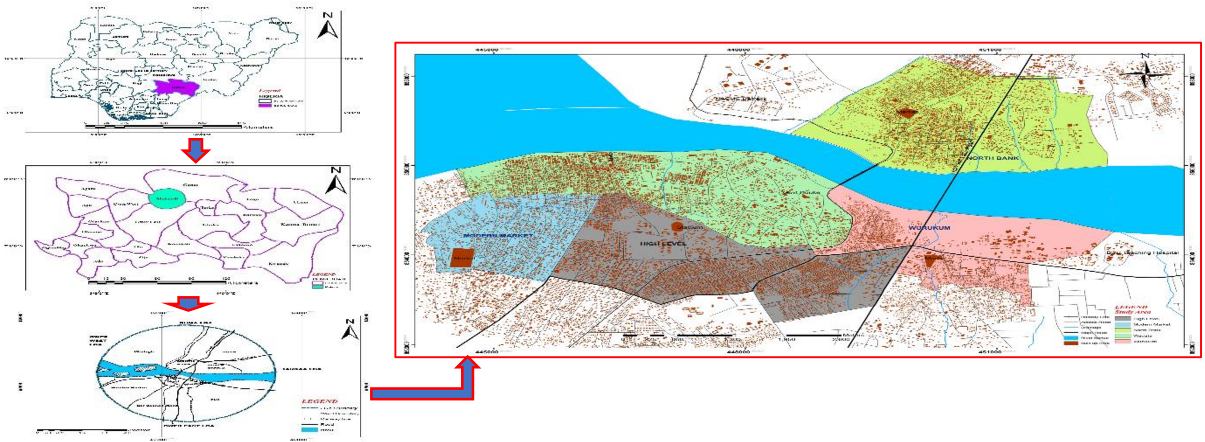

**Figure 1**: Location of Makurdi

**Data Collection and Analysis**

Data were collected on certain components of emission concentrates of pollutants from five (5) dumpsite within the neighbourhoods with the aid of handheld MSA Altair 5X Multi-gas Detector manufactured by Mine Safety Appliance Company, USA. The gas analyser device is equipped with four sensors that monitor gases in ambient air and display readings. The device has a dual sensor that provide readings for CO and $H_2S$, an oxygen sensor (it was not functional), pentane and methane. Three (3) air quality monitoring parameters - carbon monoxide (CO), Hydrogen sulphide (H2S) and methane (CH4) were determined. The level of concentrates measured in the neighbourhoods were compared with regulatory Guidelines and standards for Environmental Pollution Control in Nigeria by the Federal Environmental Protection Agency (FEPA) in 1991 stipulates emission limits of pollutants (Table 1) from stationary sources (site, process, stack and vent), and the WHO standards for air quality parameters monitoring (Rim-Rukeh, A. 2014). The guidelines prescribe safe levels of common air pollutants like suspended particulate matter (SPM), oxides of carbon, nitrogen and sulphur, volatile organic compounds (VOC) and hydrogen sulphide. Measures above the stipulated regulation is considered highly polluted and harmful to the inhabitants.

**Table 1 Nigerian Ambient Air Quality Standard**

| Air Pollutants | Emission Limits |
|---|---|
| Particulates | 250 (µg/m3) |
| $SO_2$ | 0.1 (ppm) |
| Non-methane | 160 (µg/m3) |
| CO | 11- 4 (µg/m3) or 10 (ppm) |
| NOX | 0.04 - 0.06 (ppm) |
| Photochemical Oxidant | 0.06 (ppm) |
| $H_2S$ | 10 (ppm) |
| $CH_4$ | 1000 (ppm) |

Source: FMEnv, 1991

## RESULTS AND DISCUSSION

### *Ambient Air Quality Municipal Solid Waste Management Site*

The concentrations of suspended particulate in ambient air sampled at the vicinity of the solid waste dump site in residential neighbourhoods in Makurdi metropolis is presented in Figure 2. The ambient air quality sampled shows the presence of a high concentration of toxic gases including carbon monoxide (CO), hydrogen sulphide ($H_2S$) and methane ($CH_4$) (Akpofure, 2014).

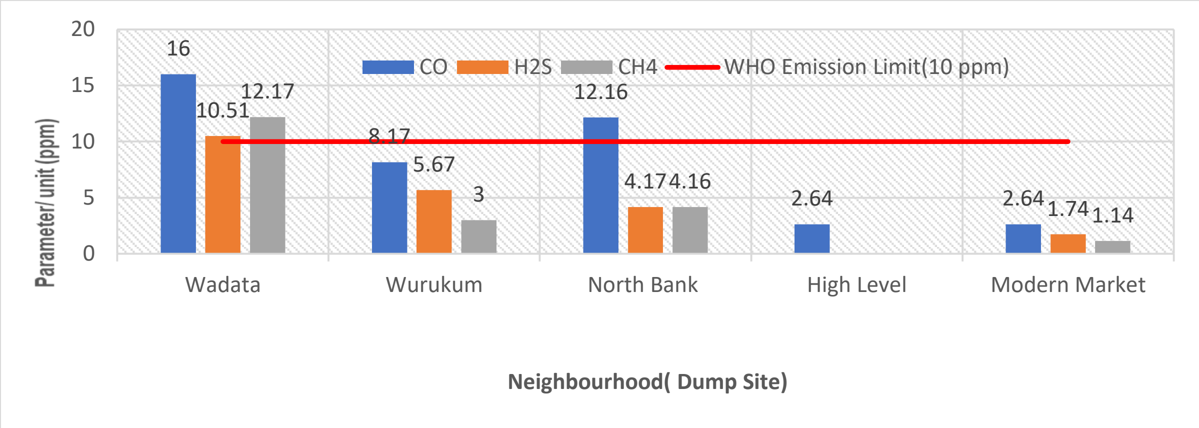


**Figure 2:** Mean Air Quality at Residential Neighbourhoods Solid Waste the Dump Sites

At the neighbourhoods' level, the mean concentration of carbon monoxide (CO) gas recorded at six different dumpsites in Wadata is 16.0ppm, Wurukum neighbourhood (*8.17ppm*), North Bank (*12.16ppm*), while both High-Level and Modern Market neighbourhoods recorded 2.64ppm of carbon monoxide in each. High CO concentration is observed in waste dump site at Wadata and North Bank neighbourhood areas (Figure 1) above the FMEnv limit of 10ppm and WHO limit of 10 – 20 ppm. At extremely high levels, CO can cause death (Kinoshita, 2020). Also, a high concentration of carbon dioxide which is a by-product of methane in the atmosphere causes the depletion of the ozone layer resulting in global warming.

Similarly, the mean concentration of hydrogen Sulphide ($H_2S$) gas recorded in the vicinity of solid waste dump site in the neighbourhoods shows the presence of a high concentration of $H_2S$ (M =10.51ppm) in Wadata. Whereas, low concentration of $H_2S$ was recorded in Wurukum (M = 5.67ppm), North Bank (M = 4.17ppm), and Modern Market (M = 1.74ppm). There is no trace of $H_2S$ at the refuse dump site in the High-Level neighbourhood. Hydrogen Sulphide ($H_2S$) is known to be immediately dangerous to life and health (IDLH). It has a pungent smell which produces a very strong rotten-egg smell even at very low concentration, but at a high concentration, the odour will no longer be detected by the human nose. The health effect of $H_2S$ in the environment includes eye, throat, and lung irritation, nausea, headache, nasal blockage, sleeping difficulties, weight loss, chest pain and aggravation of asthma (Mir, & Maurya, (2020). Humans are extremely sensitive to hydrogen sulphide odours and can smell such odours at concentrations as low as 0.5 to 1ppm (Akpofure, 2014). Hydrogen sulphide has both natural and man-made sources (such as biodegradable waste sites). Hydrogen sulphide does not have regulatory limits, because it is a "non-criteria" pollutant.

Also, the high concentration of Methane gas was recorded at the refuse dump site in Wadata (*M = 12.17ppm*), Wurukum (*M = 3.00ppm*), North Bank (*M = 4.16ppm*), Modern Market (*M = 1.14ppm*), and no trace of $CH_4$ at High-Level neighbourhood. Methane is an odourless gas and is lighter than air. Because of its lightness, it tends to rise and accumulate near the higher, stagnant parts of enclosed buildings and tightly closed manure storage pits, it is a major greenhouse gas (Akpofure, 2014).

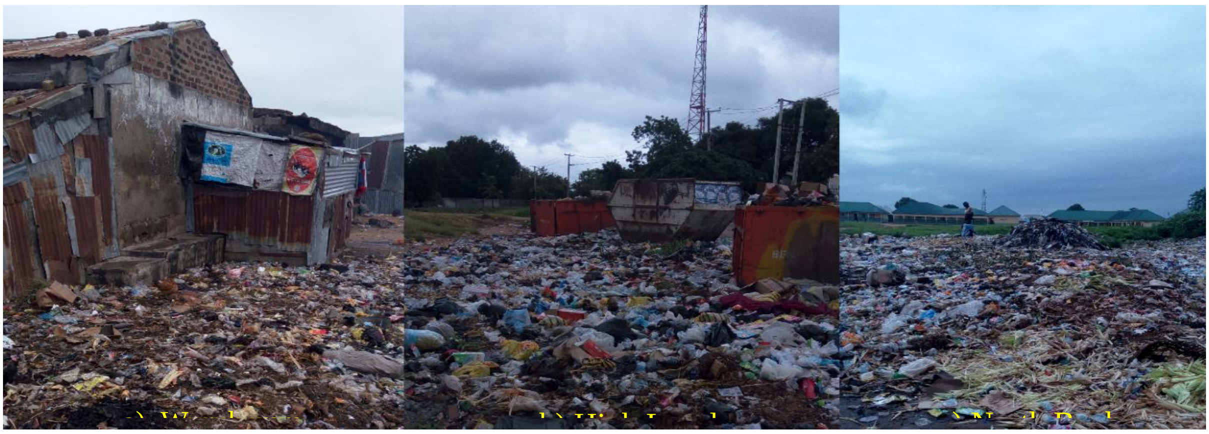

**Plate 1:** Typical Solid Waste dump in the Neighbourhood in Makurdi

## CONCLUSION

The study reveals that the CO and $H_2S$ concentrations in the ambient air were found to exceed the FMenv and WHO regulatory recommended standards. Air quality within the neighbourhoods constitutes pollutants - Carbon monoxide (CO), and hydrogen Sulphide ($H_2S$), concentration from the solid waste dumpsites. Residents are at the risk pollutants emission from the solid waste dumpsites which threaten health due to exposure through inhalation of air that can cause respiratory disorders and lung cancer in humans. Wadata and North Bank are densely-populated neighbourhoods in Makurdi. The quality of ambient air is an important concern of habitants living in proximity to the dump sites. There is a need, therefore, to develop better practices in the management of solid waste, especially the open dump sites operation and emission control. Also, the need to constantly monitor the ambient air quality in Makurdi, especially around the dumping sites to avoid harmful air pollution for the resident's safety.

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