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THE QUANTITATIVE ASSESSMENT AND HEALTH RISK OF NITROGEN OXIDES (NOX) EMISSION FROM THE BURNING OF MUNICIPAL SOLID WASTES IN BAYELSA STATE NIGERIA

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ABSTRACT

The environmental and health problem of pollutant gas pollutant gas like Nitrogen Oxide (NOx), cannot be overemphasized. This study is focused on the evaluation and health risk of NOx gas associated with some dumpsites in Yenagoa Metropolis, Nigeria. Handheld AEROQUAL meter was used for sampling the gas (Nitrogen Oxide-NOx) in 7 locations, including control station. Result shows that temperatures (29.63-31.12 °C), relative humidity (66.66–72.44%), and wind speed (0.98–4.03 m/s). Furthermore, the NOx concentrations range from; 0.01–0.72 ppm. The concentration of NOx in the control station was below detection limit. Air quality model for the health risk assessment showed that the concentration of NOx emission was largely safe, except for the stations of the central dumpsites (CDS), which was predominantly hazardous. This study therefore concludes that the anthropogenic emissions and greenhouse effects of NOx should be checked.

Key words: Air Quality, Municipal waste, Nitrogen oxides, Bayelsa State, Nigeria.

1. INTRODUCTION

Air pollution can be described as the introduction of harmful gaseous substances in exceeding concentration that are capable enough to cause harm, or infringe on ambient air quality (Angaye, 2019). It can also be seen as a process that involves an infringement on air quality by substances (pollutants) capable of harming either humans, environment or other forms of biodiversity (Brauer *et al*., 2012; Kim & Kabir, 2013).

One major cause of air pollution is anthropogenic activities that releases harmful pollutants like; Carbon monoxide, Oxides of Sulphur (SOx), Nitrogen (NOx), suspended particulates etc. Burning of unsegregated waste stream have accounted for most of such emission. Notwithstanding, the global impacts of air pollution cannot be overemphasized. Although air pollution, may result from lithogenic (i.e natural) sources, but the anthropogenic sources are mostly accounted for (USEPA, 2004; 2015).

Oxides of Nitrogen is a component combination of nitrogen oxide and Nitrogen dioxide ($NO + NO_2 = NO_x$). As reported by Rim-Rukeh (2014), based on its properties, it is a reddish-brown gas with a biting odour, whose inhalation at concentrations of 4 ppm have ability to anesthetize the nose. Wastes are substances which are regarded not further usage or benefit for consumption, production and transformation of mankind (UNEP, 2006). But to be specific, municipal solid wastes (MSWs), are also referred to as needless or ready to be discarded substances, which can be solid or semi-solid, cannot be retained for further use, as well as having no economic value or further resourceful application or value to the user (Angaye, 2019).

Globally, waste stream has continued to increase in the magnitude due to urbanization and industrialization, as well as population rise due to steady influx from rural-urban migration due to the desire of the rural populace to meet up with contemporary technology (Adejobi & Olorunnimbe, 2012). Unfortunately, the burning of municipal solid wastes releases toxic gases, including oxides of Nitrogen which impairs ambient air quality (Angaye, 2019), degenerate the ecosystem, biodiversity and affect public health (Al Sabahi *et al*., 2009). As such it has become necessary to quantify the level of Nitrogen oxides emission and the associated health risk.

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2. MATERIALS AND METHODS

2.1. Study Area

The study area is Yenagoa metropolis, which is the capital city of Bayelsa state, Nigeria. It is one of the states created by the Nigerian Federal Government in 1996. Including Yenagoa, Bayelsa State has eight local Governments Areas (LGAs) which are; Brass LGA, Ekeremor LGA, Kolokuma/Opokuma LGA, Nembe LGA, Ogbia LGA, Sagbama LGA and Southern Ijaw LGA.Yenagoa is located on latitude N04° 56' 57.8'' and longitude E006° 20' 08.2''. As at 1996, the population estimate of Yenagoa was over 300,000 (NPC 2006). Notwithstanding, the population density has since abruptly expended in a geometric manner due to the levels of urbanization and commercial activities.

2.2. Sampling of Meteorological Indicators

Air quality and meteorological parameters monitored are as followed: The sampling stations were geo-referenced using Germin etrex GPS (Taiwan). Meteorological parameters like; wind speed, temperature, relative humidity and wind direction was measured using portable hand-held Kestrel meteorological meter (4500NV-USA).

2.3. Air Quality sampling

The pollutant gas, Nitrogen (NOx), was measured using portable multiprobe AEROQUAL metre was used (Aeroqual Limited Auckland-New Zealand-Series 300). The meter was switched on and the probe was able to extract the air through a filter by suction, it is capable of converting to mass concentration every 3 minutes, with a flow rate of 2.83 L/min into measuring ranged of 1 – 10 micrograms per cubic metre mass concentration. Measurements were done by holding the portable digital meter (device) at height of about 2 meters sensor with the probe facing the prevailing wind direction, and readings recorded at stability.

2.4. Air Quality Modeling and Risk Assessment

Furthermore, health risk assessment was carried out on the NOx gas was modelled based indices of air quality and model as described by Wang *et al*., (2017) as presented in Table 1. There were slight modifications using median and geometric mean as established in literature (Ligan *et al.*, 2014). The formular for Air Quality index (AQI); is as presented below:

$$AQI = \frac{Ci}{Si} \; X\,100$$

Where AQI = Air Quality index

Ci = Individual concentration of the monitored pollutant

Si = geometric or median mean

Table 1: Range of values for thresholds of health risk assessments of AQI Index

Safe	Moderate	Unsafe for sensitive group	Unhealthy	Very Unhealthy	Hazardous
[0-50]	[51 -100]	[101 - 150]	[151 – 200]	[201 – 300]	[>300]

2.5. Statistical Analysis

All data emerging from the study were sampled in triplicates, and subjected to statistical analysis based on version 20 of SPSS. Analysis of Variance (ANOVA) was used for mean separation. Duncan multiple range Post Hoc was used to detect the significance ($p = 0.05$). Also 2015 version of Microsoft excel package was used to compute mean values and plot graph.

3. RESULTS AND DISCUSSION

The mean levels of spatial distribution of temperature amongst the stations ranged from 29.63 - 31.12°C, with significant difference ($p<0.05$) compared to the control station (Figure 1). There was no significant difference ($p>0.05$) amongst temperature values in stations at Akenpai, Etegwe and Kpansia market; but varied significantly ($p<0.05$) in comparison to the station in Opolo Market. The spatial and seasonal variation of temperatures associated with dumpsites in Yenagoa metropolis was in agreement with values (33.5 – 36.8°C), reported for Eneka dumpsite located in Port-Harcourt (Ezekwe *et al*., 2016).

Another study in Rumuolumeni dumpsite (Port-Harcourt) showed significant correlation of temperature with pollutant gases like; NO_2, NH3 and H_2S (Weli & Adekunle, 2014). The study of Ezekwe *et al*., (2016), reported that temperature and proximity to polluted site have been reported to affect to influence the fate of air pollutant. Due to temperature variation the concentrations of pollutant gases like; CH4, CO, H_2S, NH_3, PM_{10}, SO_2, around dumpsite were found to be lower in the evening compared mornings (Ubouh *et al*., 2016). The incidence of higher temperature in dry season is not farfetched as it is a typical characteristic of dry season, coupled with the unfortunate practice of open air *insitu* burning in order to minimize piles of MSWs streams.

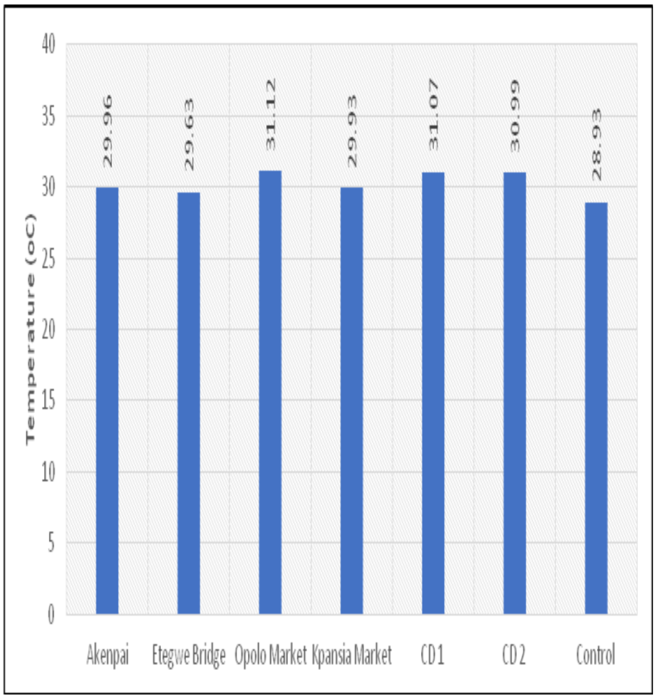

Figure 1: Temperature Levels around the Dumpsites

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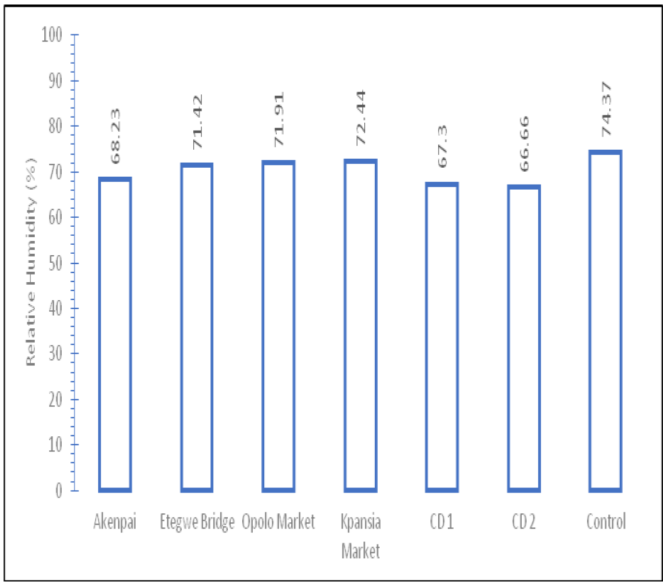

Figure 2: Levels of relative humidity around the Dumpsites

The spatial variation of relative humidity ranged from 66.66 – 72.44 %, showing significant difference ($p<0.05$) compared to the control station, which was slightly higher (Figure 2). The relative humidity values of the first station and second as well as station in Akenpai had no significant difference. But statistically dissimilar ($p<0.05$) compared to stations in Kpansia market; as well as Etegwe and Opolo market which had no significant difference between them (Figure 2)

The results on spatial and seasonal variations of relative humidity around dumpsites in Yenagoa metropolis is consistent with the study of Weli and Adekunle, (2014) with values that ranged from 62.80 - 67.9%. In their study, pollutant gases like; NO_2, NH_3 and H_2S had significantly correlation with relative humidity. This indicate that relative humidity of dumpsites can influence the fate of air pollutant. Also, relative humidity has been reported to have inverse variation with temperature (Yousif & Tahir, 2013). Relative humidity is a major parameter and influencer of air pollution (Bhaskar & Mehta, 2010). Higher relative humidity has been reported in wet season compared to dry season (Rim-Rukeh 2014).

Results on spatial variability showed that wind speed ranged from 0.98 – 4.03 m/s, with significant difference ($p<0.05$) compared to the control station (Figure 3). However, there was significant difference ($p<0.05$) between the highest and lowest values of wind speed recorded in Etegwe station and Opolo market station respectively (Figure 3). Results of this current research in Yenagoa metropolis had wind speed which was in agreement with wind speed values (1.10 – 2.4 m/s), and wind directions (South-west) reported in Portharcourt (Weli & Adekunle, 2014). The wind speed value of Yenagoa is also consistent for the dry and wet seasons with study of Uba (2015).

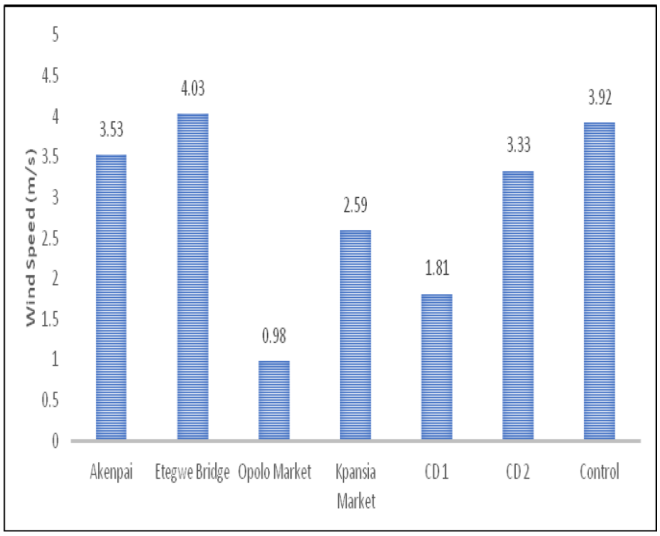

Figure 3: Levels of wind speed in the dumpsites

The meteorological parameter like wind speed plays vital role in determining the fate of pollutants gases (Cossu & Reiter 1996; Weli & Adekunle, 2014; Uba, 2015). This was corroborated by the study of Uba, (2015), who reported higher wind speed in dry season than wet season. According to Pillay *et al.*, (2011), the wind speed of any catchment area is characterized as significantly calm, when the speed limit is within the range of 0.51 - 1.8m/s.

The mean levels of NOx for spatial variation amongst the stations as presented in Figure 4.4 ranged from 0.01 - 0.72 ppm, with significant differences ($p<0.05$). But compared to the control station, there was no significant difference ($p>0.05$) amongst NOx values at Akenpai, Etegwe, Opolo and Kpansia market stations ($p>0.05$) as presented in Figure 4.

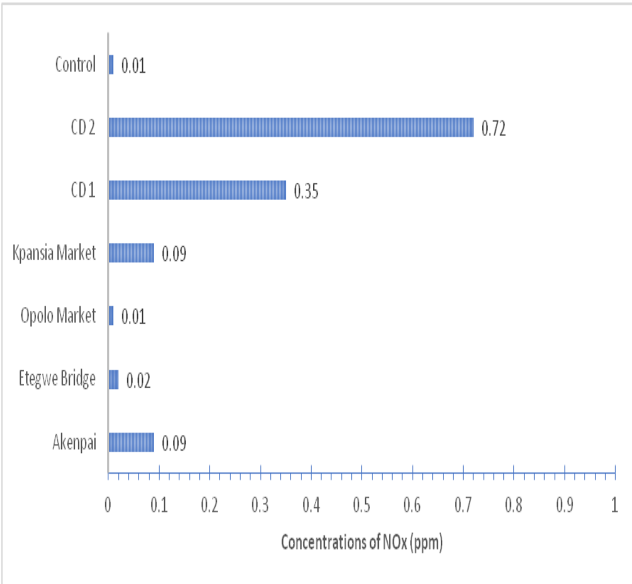

Figure 4: Levels of NOx in the dumpsites

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Table 2 Health Risk assessment of Nitrogen Oxides emission

	Median Mean Scenario		Geometric Mean Scenario	
	Dry Season	Wet Season	Dry Season	Wet Season
Akenpai	MODERATE (<100μg/m³)	SAFE (<50μg/m³)	SAFE (<50μg/m³)	SAFE (<50μg/m³)
Etegwe	SAFE (<50μg/m³)	SAFE (<50μg/m³)	SAFE (<50μg/m³)	SAFE (<50μg/m³)
Opolo Market	SAFE (<50μg/m³)	SAFE (<50μg/m³)	SAFE (<50μg/m³)	SAFE (<50μg/m³)
Kpansia Market	SAFE (<50μg/m³)	SAFE (<50μg/m³)	SAFE (<50μg/m³)	SAFE (<50μg/m³)
Central Dumpsite 1	VERY UNHEALTHY (>200μg/m³)	HAZARDOUS (>300μg/m³)	HAZARDOUS (>300μg/m³)	HAZARDOUS (>300μg/m³)
Central Dumpsite 2	HAZARDOUS (>300μg/m³)	HAZARDOUS (>300μg/m³)	HAZARDOUS (>300μg/m³)	HAZARDOUS (>300μg/m³)

The health risk assessment of NOx levels associated with the MSW dumpsite in all stations is presented in Table 2. Range of values for the modelling of AQI derived from Table 1 was used to determine the health risk based on two scenarios (median and geometric mean). Results showed that the median mean scenario health risk assessment of NOx emission was at the Akenpai station was modrate in dry season and safe in wet season. However, the geometric mean scenario indicated that the level of NOx emission was safe in both seasons (Table 2).

Results of the Median mean and Geometric mean Health risk assessments of NOx emissions in Etegwe station, as well as Opolo and Kpansia markets were generally safe throughout the seasons (Table 2). On the other hand, with the exception of the median mean scenario, which indicated a very unhealthy level of NOx emission in the first station, a hazardous Median mean and Geometric mean health risk emission of NOx was reported throughout the seasons for both central dumpsites (Table 2).

Higher level of NO_X in the range of 27.7 - 37.1 ppm was reported in dumpsite located in Delta State (Rim-Rukeh, 2014), was in contrast with Yenagoa metropolis. In Port-Harcourt the levels of NO_X reported (0.30 – 0.40 ppm), was in tandem with Yenagoa metropolis (Ezekwe *et al.*, 2016). Meanwhile, the dumpsite in Ebonyi state indicated NO_X level in the range of 0.05 – 0.12ppm, and in agreement with Yenagoa metropolis (Njoku, 2015).

The study of Uba, (2015), showed higher levels of NO_X in Zaria Metropolis (0.001 - 0.00605 ppm) than wet season (0.00185 - 0.00365 ppm), and was consistent with values of Yenagoa metropolis. The levels of NO_X in some dumpsites in Abia State were assessed, (0.04 – 0.08 ppm in the morning and 0.05 - 0.10 in the evening) results were reported were in agreement with Yenagoa metropolis Umuigwe (Nwakanma *et al.*, 2016).

Also consistent with Yengoa metropolis, were the levels of NO_X in Nekede dumpsite which ranged from 0.08 – 0.11 and 0.07 – 0.10 ppm in the morning and evening respectively (Ubouh *et al.*, 2016). Higher level of NO_X in dry season is attributed to season influence (Uba, 2015).

High level of NO_X (especially NO_2) is deleterious to plants at concentrations of 0.3 - 0.5 ppm within 10 to 20 days (Nwakanma *et al.*, 2016). Adverse effects become visible to susceptible plants at concentrations of 4 - 8 ppm within exposure time of 1 - 4 hours (Nkwocha & Pat-Mbano, 2010). The major type of NO_X that can affect humans are the nitric oxides (NO) and nitrogen dioxide (NO_2), the potential toxicity when NO gas is oxidized to NO_2 (Nwakanma *et al.*, 2016). It was reported that human exposure to around 15 ppm of NO_x can induce adverse effects like eye irritation, nose irritation, while pulmonary stress can be induced at concentration of 25 ppm in less than 1 hour (McCarlthy *et al.*, 2007).

A variety of compounding factors may have contributed to the intensity of particulate matter in the study area. For instance, some meteorological parameters (Jayamurugan *et al.*, 2013), and vehicular emissions (Araújo *et al.*, 2014), play vital roles in determining the fate and intensity of particulate matter emission. As documented in literature the major factors that affects particulate matter emission includes; domestic emission, external sources, and the meteorological indicators (Wang & Ogawa, 2015). This includes, the dry, sandy and dusty nature of the playground may be another major contributor, which is a typical characteristic of tropical region. An earlier study by Jayamurugan *et al.*, (2013) had established that temperature, relative humidity, wind speed and wind direction may have major influence the fate of air pollutants including particulate matter (Bhaskar & Mehta, 2010).

Health risk studies of PM have shown that the particulate size plays an essential role on adverse effects caused by PM concentrations (Vallius, 2005). For instance, studies show that children in proximity with higher PM concentration have a larger risk of developing allergies and asthma from the dust (Vallius, 2005).

Further studies have also shown that vehicular traffic density does not record the differences in PM toxicity between corresponding neighbourhoods; this therefore implies that particulate chemistry plays a vital role on the health effect (Vallius, 2003). According to Krewski, (2009), exposure to particulate matter have the potential to reduce life expectancy of the population by 8.6 months. Globally, it has been established in literature that particulate matter accounts for 3% of cardiopulmonary disease and 5% of lung cancer mortality (Fang *et al.*, 2013).

In addition, several authors have documented in their studies that adverse health effects of particulate matter which includes several acute and chronic presentations like; chronic respiratory imperilment and cardiovascular diseases, lung dysfunction, emergency cases and infant mortality (Samoli *et al.*, 2008; Halonen *et al.*, 2009; Guaita et al., 2011; Perez *et al.*, 2012).

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4. CONCLUSION

Environmental and Health Risk Assessment of Nitrogen Oxides (No_x) Emission Associated with the burning of Municipal Solid Waste Stream was assessed, based on Air Quality Index (AQI). In determining the AQI calculations two scenarios were applied; being median mean and control values. Unfortunately, most of the study area had significant levels of Nitrogen oxide emission (NOx). Although based on AQI modelling, most of the emissions were within the safe limit. However, emissions from the central dumpsites were mostly hazardous. Meteorological indicators like temperature, relative humidity and wind speed were assessed. The levels of NOx emission are a reflection of anthropogenic activities which must be ameliorated in order to avert adverse effects.

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