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AIR POLLUTION ASSESSMENT OF BOKO HARAM AFFECTED LOCAL GOVERNMENT AREAS OF ADAMAWA STATE, NORTH EASTERN NIGERIA

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ABSTRACT

This study is aimed at assessing the ambient air quality of Local Government Areas affected by Boko Haram insurgency. The study was conducted in both the rainy and dry seasons. Gasman portable gas monitor was used for the monitoring of CO, NO_2, SO_2, H_2S, and Cl_2. CO and H_2S were found to be within acceptable limits set by FEPA (10.00 ppm and 8.00 ppm) respectively in both seasons in all locations except Hong LGA, where CO was 11.11 ppm. NO_2, SO_2 and Cl_2 were all above acceptable limits of 0.06 ppm, 0.1 ppm and 0.01 ppm respectively. The Air Pollution Index rating indicated that all the locationswere severely contaminated, except for Michika, Madagali and the control locations which were below 100 in the rainy season. The rainy season concentrations of these pollutants are lower than the dry season due to dissolution of the pollutants by the rains. The result of the pollution level is very poor and is a threat to the health of the populace. Thus this research recommends appropriate measures to be taken to enhance a safe environment for the people in these locations for healthy human living.

Keywords: Adamawa State, Ambient air Pollution, Boko Haram, Contamination, Index, Pollution, and Rainy and dry seasons

INTRODUCTION

Common forms of pollution that affects human life are air, water and soil pollutions. Air pollution is an unwanted condition which can be defined as the presence of substances in the atmosphere in such concentrations which are harmful to man and his environment including other forms of life and valuable materials. Air pollution is the introduction of particulates, biological molecules / particulate matter or other harmful materials into the earth's atmosphere, (Jazib, 2018). Common forms of air pollutants include Carbon monoxide (CO), Sulphur dioxide (SO_2), Chlorofluorocarbons (CFCs), Nitrogen oxides (NOx) and heavy metals in form of particulates.

According to Melaku *et al*., (2008) environmental sources for pollutants include construction and demolition activities, mining and mineral processing, wind-blown dust and mobiles and transportation related activities on the road. However in urban centers generally, human generated air pollution sources can be divided into mobile and stationary (Bilos *et al*., 2001). Today, mobile source emissions have tended to be the largest contributor to air pollution in many locations.

The effect of war is detrimental to the natural environment. The application of weapons, destruction of structures, fires, transport movements, chemical spraying are all examples of destroying impact on the environment (Enzler, 2006). Some of the biggest hazards of war range from toxic dust, air pollution and green-house gas emissions (Sexena, 1990).

Boko Haram insurgency which is an irregular and an unconventional warfare is termed as terrorism. Their strategy involves the adaptation of some methods to achieve their goals. These involved bombings, kidnappings, guerilla warfare and others (Hassan 2014).

According to Intelligent Brief (Open briefing 2015) a civil society intelligence agency, stated that Boko Haram is known to possess a large number of assault rifles, rocket propelled grenades mortars and improvised bombs and shells. They also possess a large number of pickup trucks that have adapted to carry heavy machine guns. Most of their attacks were / are with the use of arm assault, in which firearms especially machine guns were the main types of weapons used. Those weapons are mostly incendiary, explosives and firearms (Pricopi, 2016). The use of these weapons releases a lot of pollutions in the air. Most of the products of these firearms and explosives are released as CO_2, CO, N_2, H_2, O_2, SO_2, CH_4, H_2S, H_2O, (Kinney and Graham, 1985)

Clean air is considered to be a basic requirement of human health and wellbeing. Air pollution has been a major environmental health problem, affecting both developed and developing countries (WHO, 2003). Human health effects of poor air quality, are far reaching, and principally affect the body respiratory system and the cardiovascular system. Individual reactions to air pollutants depend on the type of pollutants exposed to, the degree of exposure and the individual's health status and genetics (Magaji and Hassan, 2015).

This work is aimed at assessing the air quality of the Boko Haram affected Local Government Areas of Adamawa State and its implication on the health of the people in the locations. This willcreate awareness on the plight of the people in these LGAs and if remedial measures are taken, normal life, a fundamental human right will be enhanced.

MATERIALS AND METHODS

Location and Size

Adamawa state is located in the North Eastern Nigeria within latitude 7^0 26'18" to 10^0 56'57" North of the equator and longitude 11^0 23'34" to 13^0 45'50" East of the Greenwich Meridian. The state is bounded by Borno State in the North, Gombe State in the West, Taraba State in the South and Cameroun Republic in the East.

The Study area Madagali, Michika, Mubi North, Mubi South, Hong and Gombi, as designated by the legend, (**Figure 1**; map of the locations), are located within latitudes 9^0 58'10" to 10^0 56'57" North of the Equator and longitudes 12^0 40'40" to 13^0 44'56" East of the Greenwich Meridian. These Local

Government Areas are bounding each other (neighboring Local Government Areas) and collectively bounded by Borno State in the North, Girei Local Government Area in the West, Song and Maiha Local Government Areas in the South and Cameroun Republic in the East. The study area has a collective area of 414.09623 square kilometers, (Adebayo & Tukur, 1999).

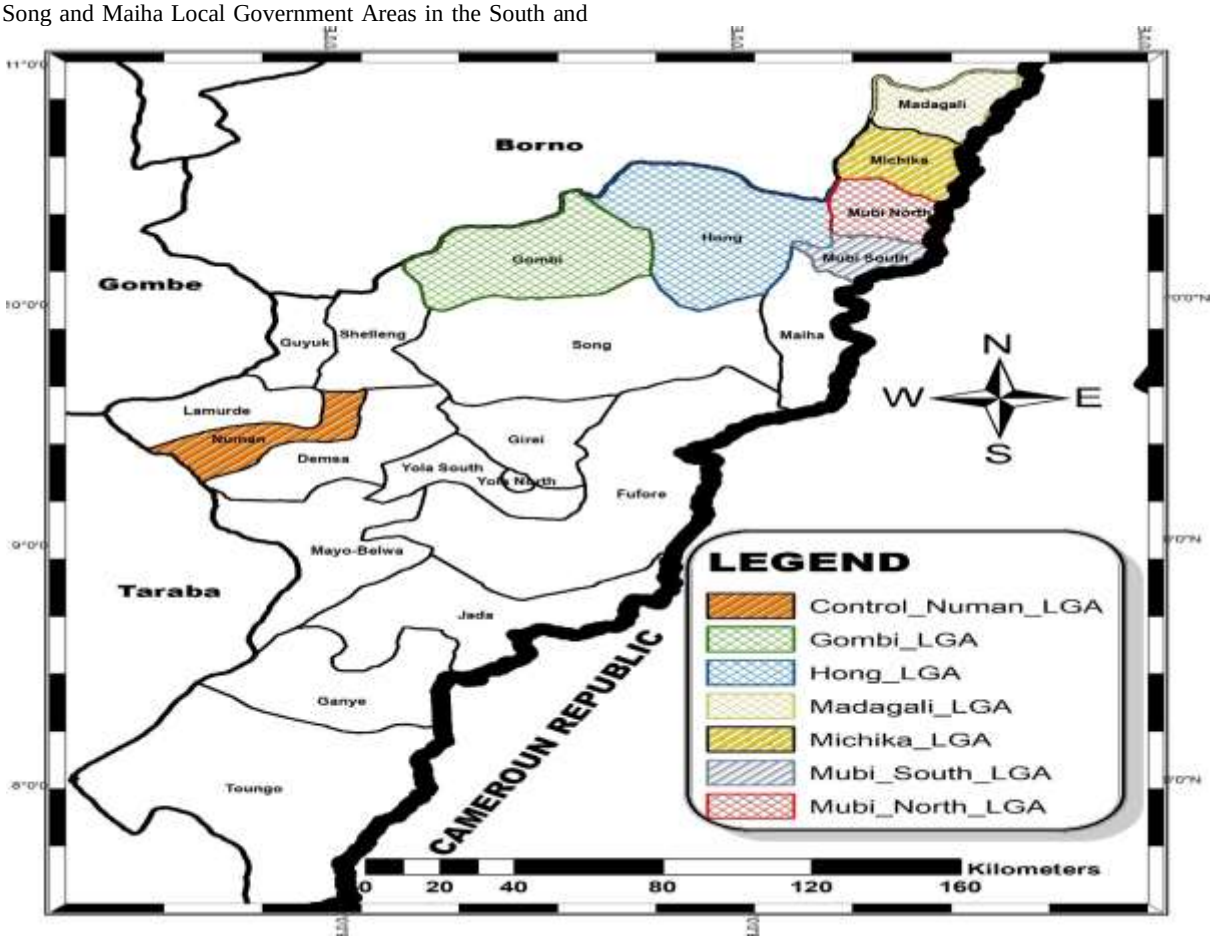

Figure 1: Map of the sample locations. (Source: Niramart Technologies, 2019).

Sampling sites were Madagali, Michika, Mubi North, Mubi South, Hong and Gombi Local Government Areas with a control in Numan Local Government, far off from the targeted areas.

The concentration of gaseous pollutants were determined on the site using mobile gas sensors manufactured by Crown Detection Instrument Ltd. Five gaseous pollutants were determined; CO, NO_2, SO_2, H_2S, and Cl_2.. The measurements were carried in both dry and rainy seasons.

The study used measurements and statistical analysis to evaluate levels of air pollutants in the area. Assessment of air pollutant impact in the study area was based on the computed exceedence factors (EF) as qi and Air pollution indices (API), FEPA (2012) and WHO (2003), comparing them with air quality standards for CO, SO_2, NO_2, H_2S and Cl_2. The exceedence factor for each pollutant was computed using equation (1) and the resultant figures compared to API (Rao & Rao, 2005) using equation (2).

$$qi = \frac{Coi}{Csi} \quad (1)$$

Where, qi = exceedence factor for I th parameter, Coi = Observed concentration of I th term and Csi = Recommended permissible standard concentration for the parameter.

CPCB (2006) has classified exceedence factor into four categories as follows;

q> 1.5 implies critical pollution (C), q between 1.0 - < 1.5 implies high pollution (H)

q between 0.5 - < 1.0 implies moderate pollution (M), and q< 0.5 implies low pollution (L).

Air Pollution Index (API) is a numerical rating that indicates how polluted each sample location is. API rating scale as adopted by Ugbebor and Yorkor (2018), categorized API into clear air, high pollution, moderate pollution, heavy pollution and severe pollution (see table 1):

API is determined using the following expression:

$$API = \frac{1}{n}\sum_{i=1}^{n} Ai \quad (2)$$

Where A = the sub-index given as:

$$Ai = 100\frac{Coi}{Csi}$$

$$= 100\ qi$$

$$API = \frac{1}{n}(100qi)$$

Table 1: API Rating Scale for Indices

S/No	Index Value	Rating	Health concern
1	0 – 25	Clear Air	Good
2	26 – 50	Light air pollution	Acceptable
3	51 – 75	Moderate air pollution	Unsatisfactory
4	76 – 100	Heavy air pollution	Unhealthy
5	>100	Severe air pollution	Severe and unhealthy

Source: Ugbebor and Yokor, (2018)

RESULTS AND DISCUSSIONS

Table 2: Mean Concentration of Air Pollutants in the dry season in ppm

Local Govt.	Pollutants				
	CO	NO_2	SO_2	H_2S	Cl_2
Mubi North	4.00	0.49	0.24	4.17	0.07
Mubi South	5.33	0.44	0.36	2.44	0.08
Michika	5.67	0.32	0.20	3.16	0.07
Madagali	6.00	0.29	0.21	2.67	0.08
Gombi	10.00	0.72	0.21	5.56	0.11
Hong	11.11	0.53	0.63	5.22	0.10
Control	5.00	0.63	0.93	3.00	0.08
Standard FEPA, (2012)	10.00	0.06	0.1	8.0	0.01

Table 3: Mean Concentration of Air Pollutants in the Rainy Season in ppm

Local Govt.	Pollutants				
	CO	NO_2	SO_2	H_2S	Cl_2
Mubi North	2.78	0.51	0.15	3.87	0.04
Mubi South	4.78	0.37	0.31	2.44	0.06
Michika	4.78	0.24	0.13	2.89	0.06
Madagali	5.33	0.28	0.14	2.39	0.05
Gombi	4.33	0.67	0.42	3.45	0.08
Hong	7.56	0.46	0.21	3.21	0.06
Control	3.25	0.31	0.11	1.11	0.02
Standard FEPA, (2012)	10.00	0.06	0.1	8.0	0.01

Table 4: Exceedence factor for Dry Season.

Local Govt.	Pollutants				
	CO	NO_2	SO_2	H_2S	Cl_2
Mubi North	0.40	8.49	24.00	0.52	7.00
Mubi South	0.53	7.33	36.00	0.31	8.00
Michika	0.57	5.33	20.00	0.40	7.00
Madagali	0.16	4.83	21.00	0.33	8.00
Gombi	1.00	12.00	21.00	0.70	11.00
Hong	1.11	8.83	63.00	0.65	10.00
Control	0.50	10.50	93.00	0.48	8.00

Table 5: Exceedence factor for Rainy Season.

Local Govt.	Pollutants				
	CO	NO_2	SO_2	H_2S	Cl_2
Mubi North	0.28	8.50	15.00	0.48	4.00
Mubi South	0.48	6.17	31.00	0.31	6.00
Michika	0.47	4.00	13.00	0.36	6.00
Madagali	0.53	4.67	14.00	0.30	5.00
Gombi	0.43	11.17	21.00	0.40	8.00
Hong	0.76	7.67	42.00	0.40	6.00
Control	0.33	5.17	11.00	0.14	2.00

From **Tables 2 and 3,** the critical pollutants are NO_2, SO_2 and Cl_2 in all locations and in both seasons, while H_2S has low pollutions in all locations in both seasons. CO is low in all locations, **table 4 and 5** except in Madagali and Hong with moderate pollution and lowest in Mubi North, like because of the few numbers of factories / industries in these locations.

Table 6: Air Pollution Index (API) for Dry and Rainy Season.

LGA	Dry Season	Rainy Season
Mubi North	161.64	113.04
Mubi South	208.68	175.84
Michika	133.20	95.32
Madagali	137.28	98.00
Gombi	183.00	248.00
Hong	334.36	143.32
Control	449.92	74.56

Air Pollution Index rating of these locations, **table 6**, signified heavy and severe pollution. Michika, Madagali and the control, fall within heavy pollution, while the rest are severely polluted. The API was lower during the rainy season, probably due to dilution of the gases by rain water. This agrees with the findings of Maitera *et al.,* (2012) that higher values in the dry season may be due to temperature inversion, wind speed, wind direction, heat and low relative humidity. Temperature inversion limits the vertical circulation of air which results in air stagnation and trapping of gaseous pollutants in these locations. Slow wind condition in dry season give rise to build up high concentrations of pollutants. The critical pollutants, NO_2, SO_2, and Cl_2 in this study (see tables 2, 3, 4, &5), can cause adverse effects on health and the environment. NO_2 is a respiratory irritant that can also corrode metal at high concentrations, Satoshi and Eldred, (2012) and lowers the oxygen carrying capacity of blood (Jazib, 2018). SO_2 is produced by burning of coal and petroleum. High concentrations of it, causes chlorosis (yellowing of leaves), and plasmolysis (damage to micro membrane and metabolic inhibition) Jazib (2018). Chlorine, Cl_2 contributes to environmental problems such as ozone depletion, global warming and acid rain. Its health implication involves mucus membrane and irritation of the respiratory tract, inflammation of the lungs, etc. (Kruti, 2020). Sources of air pollution vary, which can be due to mobile (transportation), stationary combustion, industrial process and solid waste disposal (USEPA, 1993). The areas of this study are not industrialized, so the possible sources of these high concentrations might have been from combustions, explosives released and heavy movements of vehicles which characterize the activities of Boko Haram in those locations. Nigeria has been rated fourth for air pollution across the globe and has the largest number of death due to air pollution in Africa, (Dopheide, 2019).

CONCLUSION

These locations need attention on how to remediate this high level of pollution. Continuous monitoring and creating awareness about the situation can help the communities. Different health conditions that can arise as a result of these states of pollutants should be given priority at the health sector by the federal government**.**

RECOMMENDATION

It is recommended that appropriate measures be taken to enhance a safe environment for the people in these locations for healthy human living. Either the government should think of ways of remediation of the environment or relocate the inhabitants of all the polluted areas.

CONFLICTS OF INTEREST

All the authors declare that there is no conflict of interest

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