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Ambient Air Ammonia (NH_3) Concentration in Two Solid Waste Dump Sites in Abakaliki, Ebonyi State, Nigeria

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ABSTRACT

This work monitored the level of ammonia in the ambient air of two major solid waste dump sites in Abakaliki urban, Ebonyi State, in the morning for a period of a month on the onset of wet season, using portable monitor based on electrochemical sensor. The result showed that site 1 had a relatively higher mean ammonia level of 0.152 ±0.003ppm as against 0.09 ± 0.002ppm for site 2 while the corresponding minimum levels were 0.027 ±0.001ppm and 0.03 ± 0.001ppm for site 1 and 2 respectively. The ammonia levels peak on weekends (Friday to Sunday) and the beginning of the week day (Monday). The one-way Analysis of variance of mean difference in NH_3 concentration in the two sites monitored revealed a no statistical significant difference in the mean ($p<0.05$). There is no national/ international threshold limit for ammonia but the concentrations of ammonia obtained in this study is within the values obtained in some studies in Asian and European cities reported in literature.

Keywords: Abakaliki, Ambient Air, Ammonia, Dump Sites, Portable Monitor

INTRODUCTION

Ammonia is the most abundant form of reduced nitrogen in the gas-phase within the atmosphere (Behera *et al*., 2013). Ammonia contributes to both formation of particulate and deposition of reactive nitrogen in the environment (Reis *et al*., 2009, Aneja *et al.,* 2012). The deposition of nitrogen in the form of ammonia can result in eutrophication of sensitive ecosystem and to acidification of the soil (Bouwman *et al.,* 1997). An enhanced load of nitrogen in terrestrial ecosystem has been found to correlate with loss of biodiversity and can increase ecosystem vulnerability to extreme weather and insect attacks (Behera *et al.,* 2013). NH_3 plays a decisive role in particulate formation chemistry by determining the amount of ammonium sulphate and nitrate as particulate constituents (Sharma. *et al*., 2007, Baek and Aneja, 2004). Agriculture is a major source of NH_3 as it is released from animal urine and dung and from volatilization of applied fertilizers (Miroslav and Vladimir, 1998). Although NH_3 can cause injury to plants at very high concentrations (20ppm), typical levels encountered in the atmosphere (5–25ppbv) are not considered to be harmful (Miroslav and Vladimir, 1998)

If present in sufficient amounts, ammonia can neutralize atmospheric acid vapours (sulphuric, nitric and hydrochloric) by forming salt aerosols. In air, NH_3 is the precursor gas of NH_4^+ in particles (as shown in the reactions below). The gas-to-particle conversion processes in ambient atmosphere may produce inorganic ammonium salts of ammonium bisulfate (NH_4HSO_4), ammonium sulfate ($(NH_4)_2SO_4$), ammonium nitrate (NH_4NO_3), and ammonium chloride (NH_4Cl) (Tsai *et al.,* 2014, Gong *et al*., 2013, Behera *et al.,* 2013).

The latter two reactions are reversible and the acid gases can be released under specific atmospheric conditions such as warm weather (Miroslav and Vladimir, 1998).

$$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2\,SO_4$$

$$NH_3 + HNO_3 \rightleftharpoons NH_4NO_3$$

$$NH_3 + HCl \rightleftharpoons NH_4\,Cl$$

It has been estimated that ammonia emissions from agriculture give a substantial contribution (13%) to the particulate concentration in Europe (Aneja, *et al.,* 2008, Pinder *et al.,* 2007) and thereby adds significantly to the external costs related to air pollution in Europe (Erisman and Schaap, 2004, Battye *et al.,* 2003, Werner *et al.,* 2015). According to Huang *et al*.,(2012) and Zhou *et al.,* (2015), Meng, *et al.,* (2011) more than 60% of total ammonia emission in Beijing comes from

livestock and farm-land. Other sources, including human excrement, waste disposal, biomass burning, chemical industry and traffic, totally contributed 14.9–35.5% to the total budget with vehicular source accounting for only about 5%.

Ammonia is a critical nitrogen compound that alone has a major effect on global biogeochemical nitrogen cycle, atmospheric reactions leading to particulate formation, climate change, health effects and more lasting cascading effects in the ecosystem. Hence in the recent years, the sources, transport and fate of atmospheric ammonia has been widely studied (Myhre *et al.*, 2009), due to its role in global climate change. For instance, $SO4^{2-}$ and NO_3^- aerosols have important effects on global radiation budgets because of their ability to scatter the incoming solar radiation, act as cloud condensation nuclei and indirectly increase cloud life time (Myhre *et al.*, 2009).

In some cities of the world, measurements of ambient NH_3 have been reported, for example, in Rome (Perrino *et al.*, 2002), New York city (Li *et al.*, 2006), Manchester (Whitehead *et al.*, 2007) and Barcelona (Pandolfi *et al.*, 2012)

There are currently no regulations or incentive programmes in most counties of the world including Nigeria for reduction in NH_3 emission. This is in contrast to other primary gaseous pollutants such as SO_2, NO_X and VOCs, where extensive control measures and guidelines exist for the reduction in their emissions. Extensive measures have not been taken to mitigate NH_3 emission despite the fact that all these pollutants make similar contributions to PM mass loading, visibility degradation and / or acidification / eutrophication.

MATERIALS AND METHOD

Study Area

Abakaliki is the capital of Ebonyi state. It is predominantly urban, covering a total area of 5533 km^2. According to National Population Commission (NPC) 2006 census figure, Ebonyi State had a population of 2, 176, 947, out of which the Abakaliki capital territory (ACT) consists of 271, 833. The capital territory is located between longitude 6º25/N and latitude 8º08/E (Fig.1). Urban activities in the ACT include; commercial, education and industrial development as well as rapidly expanding residential areas. Improved living standards of people in ACT due to its socio-economic development have led to the generation of enormous quantity of solid waste. Abakaliki Capital Territory is facing a crisis in solid waste management with overflowing waste in designated dumping sites that stays for days and sometimes weeks before they are cleared with attendant emitted foul odour for overstayed decaying/decomposing waste.

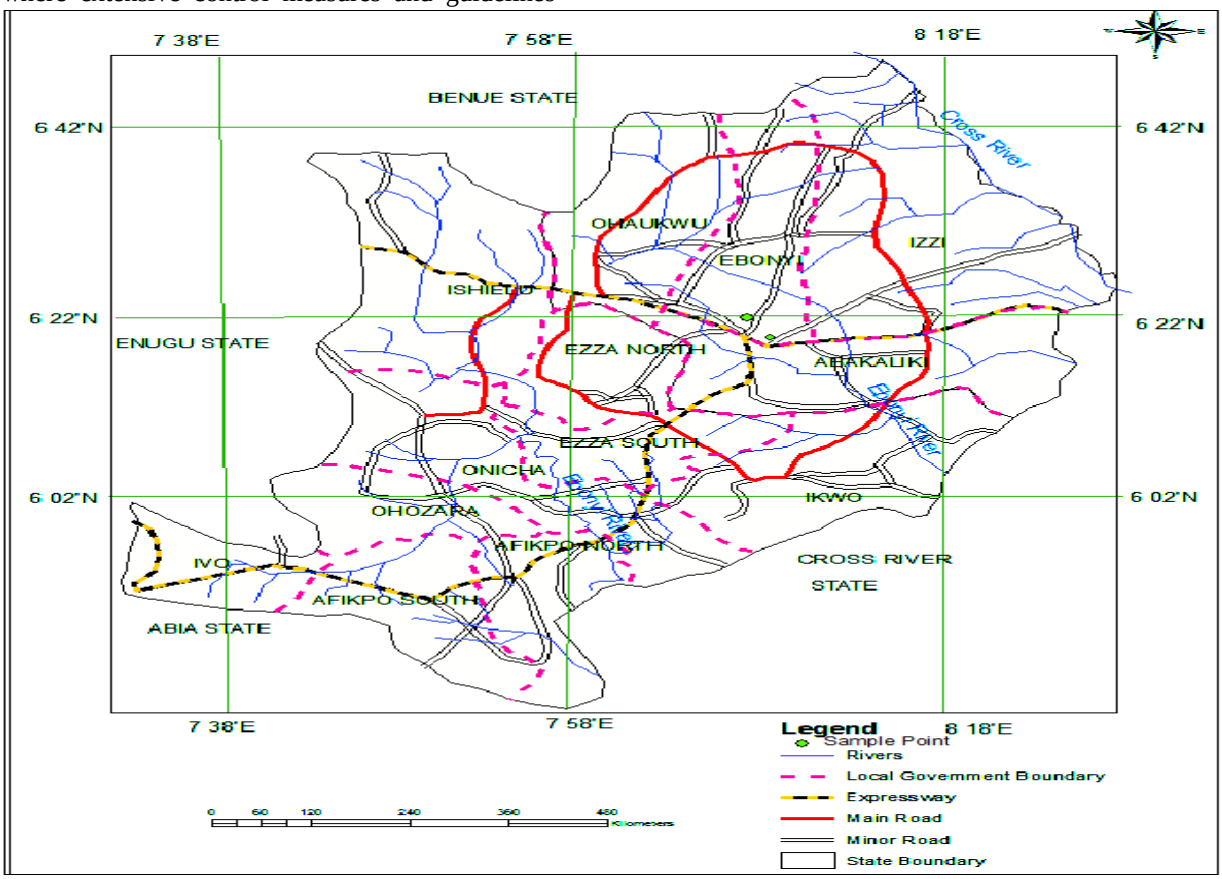

Fig. 1. Map of Ebonyi State Showing The Sampling Points

Site Selection and Monitoring Protocol

Two biggest solid waste dump sites in Abakaliki urban namely, Juju Hill by water works road dump site and Kpirikpiri market by Ogbuga road dump sites were selected for this study, because of the high volume of solid waste dumped on these sites.

Monitoring of Ammonia

The levels of ammonia at the two sites were monitored using the Crowcon Gasman ammonia portable monitor.

The instrument is equipped with NH_3 detecting electrochemical sensor. The range of detection is between O- 50ppm and the detection limit is 0.01ppm.

The monitor was switched on to the gas position and hand held to a height of two meters in the direction of the prevailing wind. The instrument reading was recorded at stability. The reading was taken in triplicate at each instance and averaged in the morning hours (8-9 am each day) in each of the sites. Huang *et al.,* (2012) had earlier reported morning and night peaking in ammonia concentration in a study in Beijing China. This study spanned for 26 days in the wet season (June, 2015).

Data Analysis

The data collected from the 26 days monitoring campaign was computed for descriptive statistics, one-way analysis of variance of mean values of NH_3 levels in the two sites using version-15 Minitab statistical software.

RESULTS AND DISCUSSION

The mean levels of ammonia in sites 1 and 2 were presented in Table 1. The maximum and minimum ammonia concentration during the 26 days monitoring in site 1 were 0.152 ±0.003 and 0.027 ±0.001ppm respectively while the corresponding values for site 2 were 0.09 ± 0.002 and 0.03 ± 0.001ppm respectively. The ammonia levels peak on weekend (Friday to Saturday) and the beginning of the week day (Monday). The maximum ammonia concentration of 0.152ppm in site 1 was recorded on Saturday (13/6/2015) while maximum in site 2 (0.09 ppm) was recorded on Monday (8/6/2015) and Thursday (13/6/2017) (Table 1 and Fig.2)

The mean concentration of ammonia in the study period gave 0.070538±0.029972 and 0.049231±0.018414 in sites 1 and 2 respectively (Table 2). The mean levels of ammonia obtained in this study were higher than the mean of 0.2ppb and range of 0.2-1.5 ppb reported by Mukhtar *et al.*,(2008) in a study using Ogawa passive sampler .The level of NH_3 in this study may be attributed to the multiple impacted nature of the sites including but not limited to agricultural (site 1is situated close to a rice farm where ammonium fertilizer is being used and Kpirikpiri market), also automobile impacted, as the two sites are situated along major roads and are further impacted by ammonia emissions from the decaying and sometimes burnt organic matter in the dump sites. This is in line with Huang *et al.,* (2012) and Zhou *et al.,* (2015), who reported that more than 60% of total ammonia emission in Beijing comes from livestock and farm-land. Other sources, including human excrement, waste disposal, biomass burning, chemical industry and traffic, totally contributed 14.9–35.5% to the total budget with vehicular source accounting for about 5%.

Table 1: Mean Levels of Ammonia from Sites 1 and 2

Day	Date	Kpirikpiri/Ogbuaga market waste dump mean NH_3 Conc. (ppm) (site1)	Juju hill/water works waste dump mean NH_3 Conc.(ppm) (site2)
Mon	1/6/2015	0.09 ±0.002	0.08 ± 0.002
Tue	2/6/2015	0.03 ±0.001	0.04 ± 0.001
Wed	3/6/2015	0.066 ± 0.002	0.05 ± 0.001
Thur.	4/6/2015	0.146 ± 0.003	0.03 ± 0.001
Fri	5/6/2015	0.095 ± 0.003	0.04 ± 0.001
Sat	6/6/2015	0.027 ± 0.002	0.05 ± 0.001
Mon	8/6/2015	0.079 ± 0.002	0.09 ± 0.002
Tue	9/6/2015	0.027 ±0.001	0.05 ± 0.001
Wed	10/6/2015	0.07 ±0.002	0.03 ± 0.001
Thur.	11/6/2015	0.05 ± 0.001	0.08 ± 0.002
Fri	12/6/2015	0.079 ±0.002	0.04 ± 0.001
Sat	13/6/2015	0.152 ±0.003	0.05 ± 0.001
Mon	15/6/2015	0.076 ± 0.002	0.03 ±0.001
Tue	16/6/2015	0.097 ±0.001	0.04 ±0.001
Wed	17/6/2015	0.05 ±0.001	0.05 ± 0.001
Thur.	18/6/2015	0.04 ± 0.001	0.09 ±0.002
Fri	19/6/2015	0.08 ±0.002	0.05 ±0.001
Sat	20/6/2015	0.06 ±0.001	0.03 ± 0.001
Mon	22/6/2015	0.07 ±0.001	0.04 ±0.001
Tue	23/6/2015	0.06 ± 0.001	0.05 ± 0.001
Wed	24/6/2015	0.06 ± 0.001	0.05 ±0.001
Thur.	25/6/2015	0.05 ± 0.001	0.07 ± 0.002
Fri	26/6/2015	0.07 ± 0.001	0.03 ±0.001
Sat	27/6/2015	0.06 ± 0.001	0.05 ± 0.001
Mon	29/6/2015	0.08 ± 0.002	0.04 ± 0.001
Tue	30/6/2015	0.07 ±0.001	0.03 ± 0.001

(NB. Monitoring was not done on Sundays).

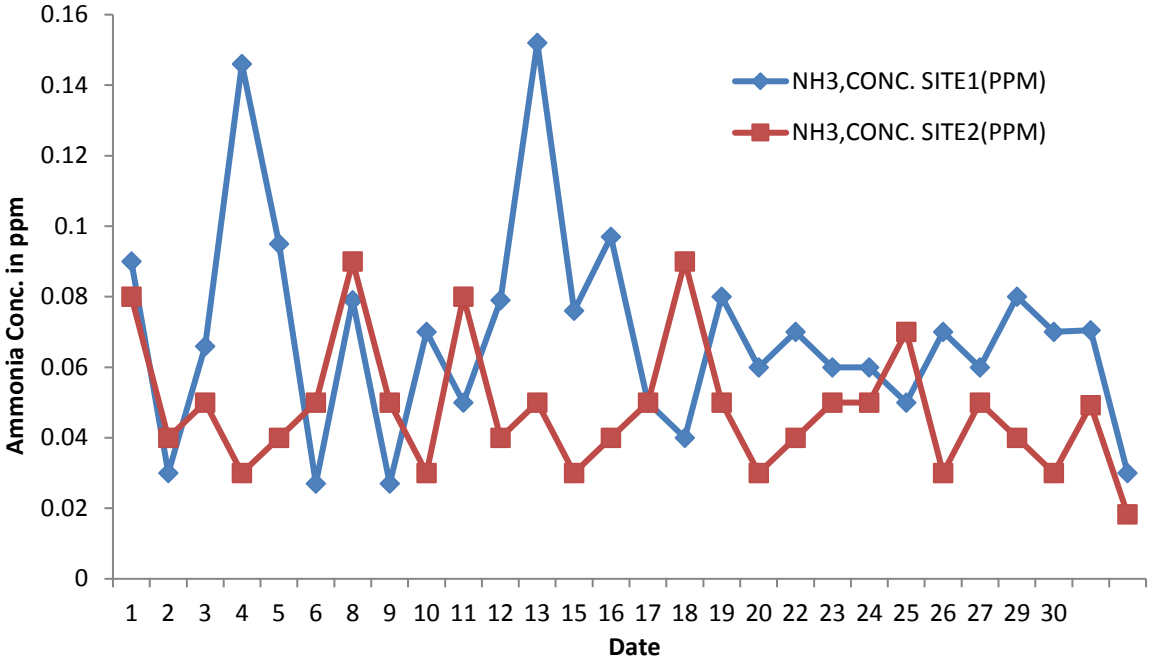

Fig. 2 Date (Day) Ammonia Levels in the two Sites within the Study Period

Table 2 Descriptive Statistics of NH_3 Concentrations (ppm) in Sites 1 and 2

Sites	N	Mean	StDev
NH3_Conc Site_1	26	0.070538	0.029972
NH3_Conc Site_2	26	0.049231	0.018314

Table 3 ONE-WAY ANOVA for NH_3 Concentration (ppm) at Sites 1 and 2

Source	DF	SS	MS	F	P
Factor	1	0.006789	0.006789	8.15	0.007
Error	40	0.033306	0.000833		
Total	41	0.040096			

Site-wise comparison showed that site 1 had the higher mean concentrations of NH_3 relative to site 2. However, one-way analysis of variance (ANOVA) for the differences in the mean levels of NH_3 in the two sites (Table 3) revealed that although there is variation in the mean levels of NH_3 in the sites, such variations were not statistically significant($p<0.05$).

CONCLUSION

This study revealed that NH_3 concentrations in sites 1 and 2 within the period of the study ranged between 0.027-0.152 and 0.03-0.09 ppm with mean of 0.152 ±0.003 and 0.09 ± 0.002 ppm for sites 1 and 2 respectively. Furthermore, the observed difference in the mean levels of NH_3 in the two sites may have occurred

by marginal difference in the emission sources in the two sites. The level of NH_3 in this work is within the values reported in literature in some Asian and European cities.

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