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Seasonal variation of meteorological factors on air parameters and the impact of gas flaring on air quality of some cities in Niger Delta (Ibeno and its environs)

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The impacts of gas flaring on meteorological factors at Ibeno, Eket, Onna, Esit Eket and Umudike - Nigeria were investigated by measuring air quality parameters. The results show that the mean concentration of air parameters value were below Federal Environmental Protection Agency (FEPA) and United States Environmental Protection Agency (USEPA) National air quality standards with exception of carbon monoxide which exceeded the limit of 35 ppm in March at Ibeno. Concentration of air parameters at Umudike showed a similar trend to that of study locations at Eket, Ibeno, Esit Eket and Onna. Air quality parameters (Cl^-, SPM and SO_2) were found to have positive correlation with vapour pressure, humidity and rainfall values in the study areas. It was also established that a positive correlation exits between NO_2, H_2S, SO_2, SPM, chloride, carbon monoxide and wind speed relative humidity, temperature and vapour pressure in the study locations. Chloride and nitrate also have a positive relationship with wind speed in some of the study locations.

Key words: Air parameters, gas flaring, meteorological factors.

INTRODUCTION

The atmosphere is a complex dynamic natural gaseous system that is essential to support life on planet Earth. Stratospheric ozone depletion due to air pollution has long been recognized as a threat to human health as well as to the Earth's ecosystems. Indoor air pollution and urban air quality are listed as two of the world worst pollution problems in the 2008 Blacksmith Institute World's Worst Polluted Places report (Anderson, 2005). Nigeria holds the highest record (19.79%) of natural gas flaring globally and is responsible for about 46% of Africa's total gas flared per tonne of oil produced. Until present, there are not less than 123 flaring sites in the region making Nigeria one of the highest emitter of green-house gases in Africa (Tawari and Abowei, 2012).

Air pollution is a mixture of solid particles and gases in the air. Car emissions, chemicals from factories, dust and

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pollen and mold spores may be suspended as particles. Some air pollutants are poisonous. Inhaling them can increase the chances of having health problems. People with heart or lung disease, older adults and children are at greater risk from air pollution. Air pollution has been identified as one of the most critical environmental problems confronting the Nigeria. Traffic, industry and gas flaring are the major air pollution sources in the region (Tawari and Abowei, 2012). More than two million premature deaths each year can be attributed to the effects of urban outdoor and indoor air pollution and these effects are more prominent in developing countries (Mabahwi et al., 2014). Pollution of air has great influence on living organisms and man in particular. Alarming quantity of gases and smoke are discharged daily into the atmosphere. Globally, the pollutants which account for almost 98% of the total pollution are carbon monoxide 52%, sulphurdioxide 18%, hydrocarbon 2%, particulates 10% and oxides of nitrogen, 6%.

Hydrogen sulphide (H_2S) is emitted from a number of metallurgical, petroleum and petrochemical processes. Fugitive emission of hydrogen sulphide can occur from sour gas wells and certain petrochemical processes. It is a highly toxic gas due to its chemical asphixant characteristics. Despite its strong rotten egg odour, it is often difficult to detect at high concentrations due to rapid olfactory fatigue. Hydrogen sulphide is highly soluble in water and can be easily oxidized to form sulphur dioxide (Aliyu et al., 2013). Sulphur emissions influence the level of acidification of soils and freshwater ecosystems (Aliyu et al., 2013), climate change (Aliyu et al., 2013) and have impacts on human health (Aliyu et al., 2013). SO_2 is oxidized to SO_3 in the atmospheric air by photolytic and catalytic processes involving ozone, oxides of nitrogen (NO_x) and hydrocarbon (HC), giving rise to the formation of photochemical smog. Under normal conditions of the atmosphere, SO_3 reacts with H_2O vapour to produce droplets of H_2SO_4 aerosol which give rise to the so called 'acid rain' causing damage to vegetation and materials. If the concentration of SO_2 is higher along with other gaseous pollutants in the troposphere and continues to accumulate over time, the overall concentration can have a negative effect on health, vegetation and structures (Abdul Raheem et al., 2009)

This study investigate the impact of gas flaring on air quality of some cities in Niger Delta, a case study of Ibeno and its environs in Akwa Ibom State and the seasonal variation of meteorological factors on air parameters was also investigated.

MATERIALS AND METHODS

Study area

Ibeno, Eket, Onna and Esit Eket as the main study area are located in the Niger Delta region of Nigeria. Ibeno is located at latitude 04° 33' N and longitude 08° 00' E, Eket is located at latitude 04° 38' N and longitude 07° 56' E, Onna is located at 04° 37' N and longitude 07° 51' E, Esit Eket is located at latitude 04° 39' N and longitude 08° 03' E all in in Akwa Ibom State. This area experiences a tropical climate consisting of rainy season and dry season. Onshore south-westerly winds are experienced throughout the year, due to the maritime location of the study area (Figure 1). Umudike in Abia State was chosen as the control location for this study.

Sample collection

Air parameters were sampled from March 2007 to November 2007 with the months of March, April, October and November representing dry season and May to September representing rainy season. The sampling locations were labeled; Eket, Esit Eket, Ibenno, Onna and Umudike (control sample).

Determination of air quality parameters

Crowcon Gasman Monitors were used for the determination of the ambient concentration of air parameter in each location. It operates by gas diffusion through an air filter into the sensors which is fitted directly under the air filter. The concentration of air parameters is then displayed on the output meter. The instrument is calibrated before use and was moved from one site to the other between the hours of 8 am to 12 pm.

Determination of meteorological factors

Meteorological data for the sampling location were collected in Umudike, Eket, Ibeno, Onna and Esit Eket from January, 2006 to July 2007 using standard meteorological instruments.

RESULTS AND DISCUSSION

Mean concentration of H_2S ranges from 0.15 ± 0.05 - 0.40±0.12 ppm, Eket; 0.15 ± 0.02 - 0.50 ± 0.03 ppm, Esit eket; 0.15 ± 0.08 - 0.40 ± 0.12 ppm, Ibeno; 0.10 ± 0.02 - 0.25 ± 0.11 ppm, Onna and 0.15±0.01 - 0.35 ± 0.10 ppm in Umudike (Table 2). H_2S were present in all the study locations at a lower quantity. This shows that there are other contributory factors to emission of H_2S such as fumes from automobile exhaust and power generators. Results obtained was lower than results (with the range from 0.18 - 0.76) obtained by Aliyu et al. (2013).

Mean concentration of NO_2 ranges from 0.20±0.02 – 0.60±0.03 ppm, Eket; 0.10±0.01 - 0.60 ± 0.11 ppm, Esit Eket; 0.20±0.04 - 0.65±0.06 ppm, Ibeno; 0.23±0.01 - 0.50±0.14 ppm, Onna and 0.28±0.08 - 1.00±0.04 ppm in Umudike (Table 1). NO_2 is recorded in all study locations. Higher concentration in Umudike may be due to the use of fertilizer in agriculture while that of Ibeno, Eket, Onna and Esit Eket may be as a result of sea spray.

Mean concentration of SO_2 in the study locations shows the same trend of being higher during dry season and lower concentration during rainy season. This is due to dilution effect of rain on the atmosphere. Its values ranges from 0.95 ± 0.06 – 2.00 ± 0.11 ppm, Eket; 1.00 ± 0.10 - 3.00 ± 0.07 ppm, Ibeno; 0.95 ± 0.04 – 2.00 ±0.12 ppm, Esit; 1.00 ± 0.02 – 2.00 ± 0.01 ppm, Onna and 1.10 ± 0.11 – 2.40 ± 0.01 ppm, Umudike (Table 3). The results

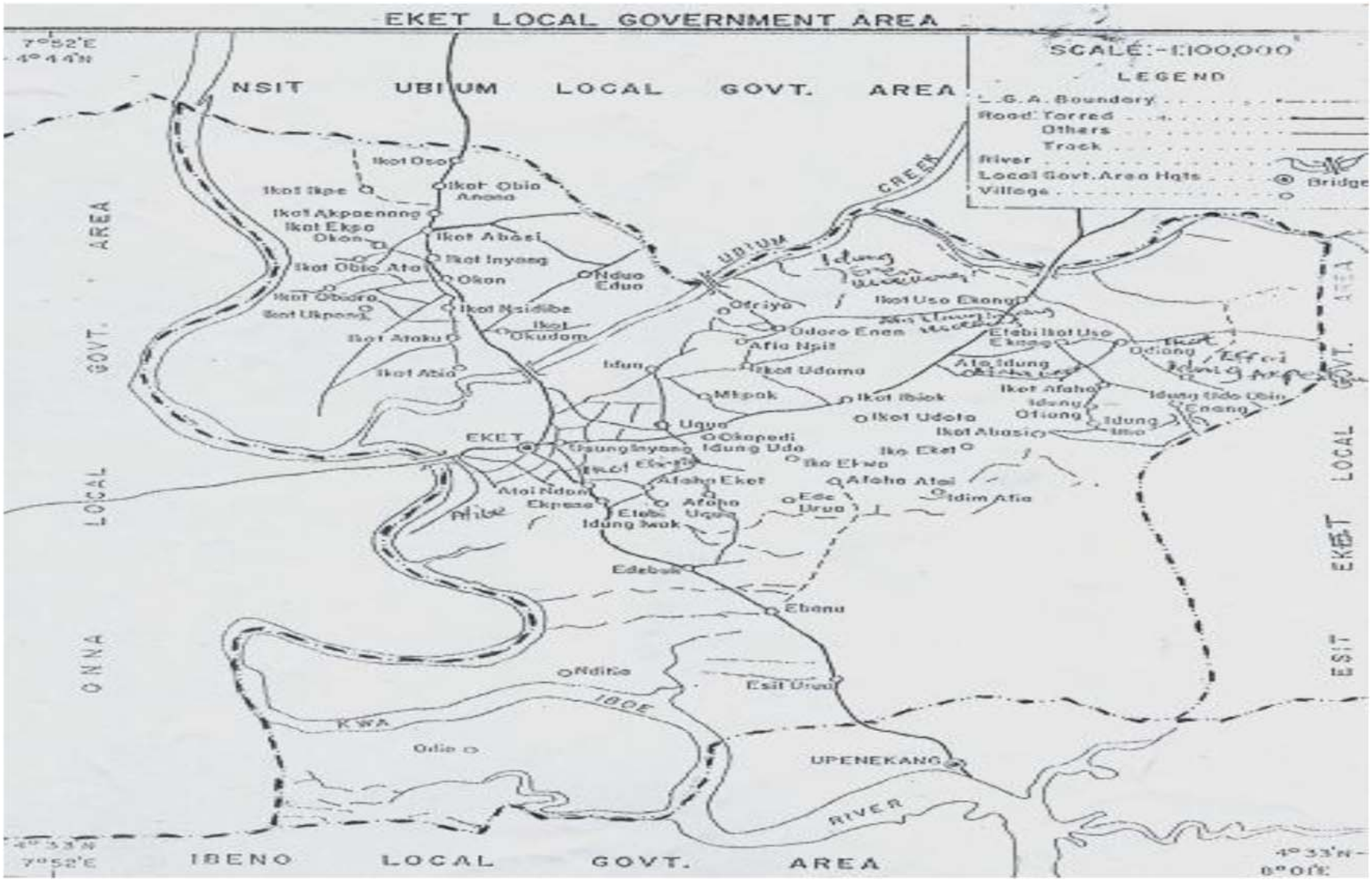

Figure 1. MAP showing sampling locations in Akwa Ibom and Abia State.

Table 1. Mean concentration ± standard deviation (ppm) of NO_2 in the studied area.

Period	Eket	Esit Eket	Ibeno	Onna	Umudike
March	0.40±0.01	0.40±0.06	0.40±0.11	0.45±0.12	0.30±0.01
April	0.40±0.02	0.35±0.09	0.30±0.09	0.40±0.04	0.40±0.11
May	0.30±0.04	0.30±0.03	0.30±0.07	0.30±0.08	0.30±0.06
June	0.20±0.02	0.10±0.01	0.20±0.04	0.25±0.02	0.28±0.08
July	0.25±0.02	0.10±0.01	0.20±0.04	0.23±0.01	0.30±0.02
August	0.40±0.01	0.20±0.02	0.60±0.01	0.30±0.05	0.55±0.01
October	0.60±0.03	0.50±0.08	0.65±0.06	0.50±0.14	1.00±0.04
November	0.60±0.03	0.60±0.11	0.60±0.10	0.40±0.11	0.80±0.02

obtained in the dry season (March, April, October and November) were higher than that of rainy season (May to August). Higher values during dry season may be attributed to vehicular emissions, refuse dump and other combustion activities within the area. SO_2 is known as an acid precursor and was identified in all samples studied. The concentration of SO_2 is lower than ranges of 3.21 – 5.18, 7.4 – 15.5 and 16 – 64 ppm reported by Ettouney et al. (2010) and Kalabokas et al. (1999), respectively but was higher than range of 0.03 – 0.09 ppm reported in Kano metropolis, Nigeria (Okunola et al., 2012) and range of 0.022 – 0.087 ppm reported by Aliyu et al. (2013). Comparing data with the FEPA standard level of 0.06 ppm, the results obtained from this study was found to be higher.

Mean concentration of carbon monoxide (CO) ranges from 15.00±0.02 – 33.40 ± 0.15 ppm, Eket; 17.00 ± 0.01 – 33.10 ± 0.11 ppm, Esit Eket; 12.50 ± 0.02 – 36.80 ±0.12 ppm, Ibeno; 16.50 ± 0.01 – 30.90 ± 0.06 ppm,

Table 2. Mean concentration ± standard deviation (ppm) of H_2S in the studied area.

Period	Eket	Esit Eket	Ibeno	Onna	Umudike
March	0.30±0.11	0.20±0.02	0.28±0.05	0.20±0.04	0.35±0.10
April	0.30±0.14	0.15±0.02	0.22±0.02	0.15±0.01	0.20±0.08
May	0.15±0.05	0.20±0.01	0.15±0.08	0.10±0.02	0.15±0.01
June	0.20±0.02	0.20±0.02	0.20±0.01	0.20±0.06	0.18±0.04
July	0.22±0.01	0.30±0.01	0.18±0.11	0.17±0.08	0.20±0.04
August	0.40±0.12	0.50±0.03	0.25±0.04	0.10±0.01	0.23±0.07
October	0.30±0.08	0.20±0.01	0.30±0.08	0.25±0.11	0.30±0.09
November	0.30±0.04	0.30±0.01	0.40±0.12	0.10±0.02	0.32±0.11

Table 3. Mean concentration ± standard deviation (ppm) of SO_2 in the studied area.

Period	Eket	Esit Eket	Ibeno	Onna	Umudike
March	2.00±0.01	2.00±0.02	2.00±0.04	2.00±0.02	2.20±0.02
April	1.80±0.08	1.00±0.02	3.00±0.01	2.00±0.01	2.00±0.05
May	1.10±0.02	2.00±0.01	2.00±0.08	1.00±0.02	2.00±0.14
June	1.00±0.05	0.95±0.04	1.00±0.10	1.00±0.02	1.10±0.11
July	0.95±0.06	1.00±0.01	1.20±0.11	1.20±0.01	1.30±0.12
August	1.00±0.09	2.00±0.12	2.00±0.09	1.50±0.01	1.50±0.08
October	2.00±0.03	1.00±0.08	3.00±0.07	2.00±0.03	2.00±0.04
November	2.00±0.11	1.00±0.06	3.00±0.04	2.00±0.01	2.40±0.01

Table 4. Mean concentration ± standard deviation (ppm) of CO in the studied area.

Period	Eket	Esit Eket	Ibeno	Onna	Umudike
March	27.00±0.01	33.10±0.11	36.80±0.12	30.90±0.06	13.20±0.01
April	33.40±0.15	25.50±0.09	33.50±0.08	23.00±0.09	12.50±0.01
May	20.00±0.08	25.20±0.07	28.50±0.04	21.00±0.03	8.00±0.03
June	19.70±0.06	25.00±0.04	13.40±0.01	18.70±0.11	7.00±0.01
July	15.00±0.02	23.50±0.04	12.50±0.02	16.50±0.01	7.20±0.02
August	21.00±0.02	17.00±0.01	18.00±0.05	19.20±0.08	7.50±0.01
October	24.30±0.01	27.00±0.08	28.80±0.14	21.00±0.02	15.90±0.02
November	25.20±0.04	28.00±0.10	30.00±0.11	24.00±0.05	14.00±0.02

Onna and 7.00 ± 0.01 – 15.90 ± 0.02 ppm, Umudike (Table 4). It shows the same seasonal pattern with other air pollutants measured in the study. Higher concentration of carbon monoxide may be from vehicular emission and gas flaring at Ibeno, Eket, Esit Eket and Onna. Umudike recorded lower concentration of carbon monoxide than Ibeno, Eket, Esit Eket and Onna. Carbon monoxide was higher than USEPA national ambient temperature in March 2007 at Ibeno which may be due to higher industrial activities in this area. Barman et al. (2008) conducted a study on the ambient air quality of the city Lucknow, India during Diwali festival. On Diwali day, 24-h average concentration of SO_2 was found to be 139.1 $\mu g/m^3$ (0.05 ppm) and this concentration was found to be higher at 1.95 and 6.59 times higher when compared with the respective concentration of Pre Diwali and normal day. On Diwali night (12-h) mean level of SO_2 was 205.4 $\mu g/m^3$ (0.074ppm) which was 2.82 times higher than the daytime concentration.

Mean concentration of HCN is lower at Umudike than Eket, Esit Eket, Ibeno and Onna. It ranges from 1.00±0.03 – 8.00±0.06 ppm, Eket; 1.00 ± 0.08 – 8.00 ± 0.06 ppm, Esit Eket; 1.00 ± 0.01 – 6.00 ± 0.03ppm, Ibeno; 1.50 ± 0.05 – 5.00 ± 0.08ppm, Onna and 1.00 ±

Table 5. Mean concentration ± standard deviation of SPM/(mg/m^3) in the studied area.

Period	Eket	Esit Eket	Ibeno	Onna	Umudike
March	0.18± 0.01	0.24±0.02	0.35± 0.01	0.28±0.01	0.10±0.01
April	0.15±0.02	0.13±0.02	0.35±0.11	0.25±0.06	0.23±0.09
May	0.13±0.04	0.20± 0.01	0.24±0.07	0.23±0.06	0.15±0.01
June	1.80±0.09	0.21±0.03	0.24± 0.04	2.10±0.02	0.18±0.02
July	1.50±0.06	0.20±0.05	0.26±0.03	1.70±0.08	0.20± 0.01
August	0.22±0.04	0.24± 0.01	0.32± 0.01	0.26±0.09	0.20±0.04
October	0.28±0.01	0.30±0.08	0.49±0.03	0.28±0.11	0.25±0.06
November	0.28±0.04	0.50±0.08	0.50±0.02	0.22±0.01	0.22±0.01

Table 6. Mean concentration ± standard deviation (ppm) of NH_3 in the studied area.

Period	Eket	Esit Eket	Ibeno	Onna	Umudike
March	1.20±0.06	1.00±0.12	1.00±0.02	1.30±0.06	0.92±0.04
April	1.30±0.07	1.00±0.08	1.00±0.08	1.10±0.09	0.85±0.01
May	0.98±0.13	0.98±0.07	0.90±0.04	1.00±0.02	0.75±0.02
June	0.92±0.04	0.95±0.09	0.88±0.11	0.80±0.11	0.70±0.02
July	0.85±0.01	0.93±0.04	0.90±0.05	0.86±0.05	0.66±0.01
August	0.94±0.02	0.98±0.08	0.95±0.14	0.85±0.03	0.68±0.04
October	1.10±0.03	1.10±0.01	1.08±0.03	0.99±0.08	0.98±0.05
November	1.40±0.02	1.30±0.01	1.20±0.06	1.00±0.01	1.10±0.01

Table 7. Mean concentration ± standard deviation (ppm) of HCN in the studied area.

Period	Eket	Esit Eket	Ibeno	Onna	Umudike
March	1.20±0.01	1.50±0.12	1.00±0.01	2.00±0.09	1.00±0.06
April	1.30±0.01	1.00±0.08	1.00±0.15	3.50±0.11	3.00±0.09
May	1.00±0.03	1.50±0.04	2.00±0.08	1.50±0.05	1.00±0.03
June	3.00±0.02	3.00±0.01	3.00±0.04	3.00±0.07	2.00±0.05
July	2.70±0.02	2.50±0.14	3.60±0.06	3.10±0.01	1.90±0.02
August	4.50±0.01	8.00±0.06	6.00±0.03	5.00±0.08	2.00±0.05
October	2.50±0.04	2.50±0.02	3.00±0.02	3.00±0.01	2.50±0.01
November	2.70±0.01	3.00±0.05	4.00±0.01	3.00±0.04	2.50±0.11

0.06 – 3.00 ± 0.09ppm, Umudike (Table 7). Higher concentrations were recorded in Esit Eket, Ibeno, Onna and Eket in the month of August. This may attributed to the sea spray.

Mean concentration of ammonia (NH_4) ranges from 0.85 ± 0.01 – 1.40 ± 0.20 ppm, Eket; 0.93 ± 0.04 – 1.30 ± 0.01 ppm, Esit Eket; 0.88 ± 0.11 – 1.20 ± 0.06 ppm, Ibeno; 0.80 ± 0.11 – 1.30 ± 0.06 ppm, Onna and 0.66 ± 0.01- 1.10 ± 0.01 ppm, Umudike (Table 6). Concentrations of ammonia were recorded in all location with higher volume during dry season and lower volume during rainy season. The presence of ammonia in the study locations may be linked to the use of fertilizers during agricultural activities in Umudike and sea spray for Eket, Ibeno, Onna and Esit Eket.

Mean concentration of SPM in the study area ranges from 0.13 ± 0.04 – 1.80 ± 0.09 mg/m^3, Eket; 0.13 ± 0.02 – 0.50 ± 0.08 mg/m^3, Esit Eket; 0.24 ± 0.07 – 0.50 ± 0.08 mg/m^3, Ibeno; 0.22 ± 0.02 – 2.10 ± 0.03 mg/m^3, Onna; and 0.10 ± 0.01 – 0.25 ± 0.06 mg/m^3, Umudike (Table 5). These results are below FEPA limits. Presence of SPM may be from dust particle; gas flaring and vehicular emission in Ibeno, Eket, Onna and Esit Eket and it may be due vehicular emissions or bush burning at Umudike.

Table 8. Mean concentration ± standard deviation (ppm) of Cl^- in the studied area.

Period	Eket	Esit Eket	Ibeno	Onna	Umudike
March	0.10±0.06	0.10±0.01	0.30±0.11	0.30±0.01	0.50±0.12
April	0.10±0.09	0.10±0.12	0.70±0.08	0.20±0.01	0.50±0.08
May	0.05±0.03	0.10±0.08	0.20±0.07	0.20±0.03	0.30±0.04
June	0.08±0.11	0.05±0.06	0.20±0.04	0.20±0.01	0.23±0.01
July	0.10±0.01	0.10±0.02	0.25±0.04	0.21±0.02	0.21±0.02
August	0.20±0.08	0.20±0.02	0.40±0.01	0.40±0.01	0.20±0.05
October	0.30±0.02	0.20±0.01	0.30±0.08	0.30±0.02	0.30±0.14
November	0.30±0.05	0.25±0.04	0.30±0.10	0.30±0.02	0.35±0.11

Table 9. Model summary for vapour pressure.

Station	NO_2	H_2S	SO_2	HCN	SPM	C^{l-}	CO	NH_3
Umudike	+	-	-	NE	-	+	+	-
Eket	NE	-	-	-	-	+	+	-
Ibeno	-	+	-	-	-	+	+	NE
Onna	NE	-	+	-	+	+	-	-
Esit Eket	NE	-	+	-	+	+	-	-

R^2 = 1.00, R = 1.00, dependent variable: vapour pressure, NE = no effect.

Table 10. Model summary for relative humidity.

Station	NO_2	H_2S	SO_2	HCN	SPM	Cl^-	CO	NH_3
Umudike	+	+	+	NE	+	-	+	-
Eket	NE	+	-	-	+	+	+	-
Ibeno	+	+	+	-	-	-	-	NE
Onna	NE	-	+	-	+	+	-	-
Esit Eket	NE	-	-	+	+	+	+	-

R^2 = 1.00, R = 1.00, dependent variable: humidity, NE = no effect.

Fine particles in the atmosphere provide suitable loci for various atmospheric conditions to occur. Water forms fine films which dissolves or absorbs various contaminants presence in the atmosphere which reacts with each other. When two or more than two particles fuse, higher and heavier particles are formed. Being heavier they tend to drift down and cause dry precipitation. The entire content of the atmosphere can be wash down by rain or dew, thus acid rain is caused. Results obtained were found to be higher than concentration of PM10 ranging from 70.00 – 326.75 and 41.61 – 157.65 µg/m^3 in dry and wet seasons, respectively (Babatunde et al., 2013).

Mean concentration of Cl^- in the study area ranges from 0.05±0.03 - 0.30±0.05 ppm, Eket; 0.05±0.06 - 0.25±0.04 ppm, Esit Eket; 0.20±0.04 - 0.70±0.08 ppm, Ibeno; 0.20±0.01 - 0.40±0.01 ppm, Onna and 0.20±0.05 - 0.50 ± 0.12 ppm in Umudike (Table 8). Chloride was generally high in the month of March, April, October and November while lower concentrations were recorded in the month of May – August. The source of chloride in the study area may be attributed to influence of marine environment while further study need to be carried out to determine the source of chloride at Umudike.

The regression analyses on seasonal variation of meteorological factors on air parameters (Tables 9 to 13) were calculated. The model revealed that the correlation between of the dependent variable vapour pressure (Table 9) in Umudike and the independent variables of NO_2, H_2S, Cl^-, SO_2, NH_3, SPM and CO is 1.00. This revealed that a strong positive relationship exist between the dependent variable and the independent variables. The R^2 value of 1.00 indicates that degree of variance between the dependent and the independent variables is 100%. The result shows that the coefficients of NO_2, Cl^-, CO are positive; this means that they are positively related to vapour pressure. As such, when the amounts of NO_2,

Table 11. Model summary for temperature.

Station	NO_2	H_2S	SO_2	HCN	SPM	Cl^-	CO	NH_3
Umudike	-	+	+	NE	-	+	+	+
Eket	NE	-	+	+	-	-	-	+
Ibeno	+	+	+	-	-	-	-	NE
Onna	NE	-	+	-	+	+	-	-
Esit Eket	NE	-	-	+	+	+	+	-

R^2 = 1.00, R = 1.00, dependent variable: temperature, NE = no effect.

Cl^-, CO in the air increase, the vapour pressure of the area also increases. The coefficient of H_2S, SO_2, NH_3, SPM are negative showing a decrease in vapour pressure as their volume increases. In Eket, the result indicates that the correlation between the dependent variable of vapour pressure and the independent variables of H_2S, Cl^-, SO_2, HCN, NH_3, SPM and CO is 1.00. The R^2 value of 1.00 indicates that degree of variance between the dependent and the independent variables is 100%. It therefore implies that changes in vapour pressure in the study area are highly accounted for by H_2S, Cl^-, SO_2, HCN, NH_3, SPM and CO. The result shows that the coefficient of H_2S, SO_2, HCN, NH_3, SPM are negative; this means that they are negatively related to vapour pressure. As such when their volume of in the air increases the vapour pressure will drop.

The coefficient of Cl^- and CO is positive, indicating that a positive relationship exists between them and vapour pressure. Their increase brings about an increase in vapour pressure of the area. In Ibeno, It could be observed that the R-value is 1.00. It shows that there exists a positive correlation between the dependent variable of vapour pressure and the independent variables of NO_2, H_2S Cl^-, SO_2, SPM, HCN and CO. Also the R^2 value of 1.00 revealed that, the percentage of variance of the dependent variable accounted for the independent variable which is 100%. It implies that vapour pressure in Ibeno is 100% caused by NO_2, H_2S, Cl^-, SO_2, SPM, HCN and CO. The coefficients of NO_2, Cl^-, SO_2, SPM, HCN are negative showing that they are negatively related to vapour pressure in this research area while H_2S, Cl^-, CO are positively related to vapour pressure. It means that the vapour pressure of the area increases as H_2S, Cl^-, CO in the air increases in this location. In Esit Eket, the results revealed that the R-value is 1.00. It shows that there exists a positive correlation between the dependent variable of vapour pressure and the independent variables of H_2S Cl^-, SO_2 HCN, NH_3 SPM and CO. Also, the R^2 value of 1.00 revealed that, the percentage of variance of the dependent variable accounted for by the independent variable is 100%. It implies that vapour pressure in Esit Eket is 100% caused by H_2S Cl^-, SO_2, HCN, NH_3 SPM and CO. The coefficient of H_2S, HCN, NH_3 and CO are negative, this imply that there is a negative relationship between them and vapour pressure (Table 4 and 6). It shows that when their volume in air increases the tendency for vapour pressure to increase is low. The coefficient of Cl^- , SO_2, SPM are positive showing that vapour pressure will likely increase as Cl^-, SO_2, SPM in air in this study location increases.

The result in Table 11 revealed that the correlation between of the dependent variable of temperature and the independent variables of NO_2, H_2S, Cl^-, SO_2, NH_3, SPM and CO is 1.00. In Umudike, the R^2 value of 100 indicates that degree of variance between the dependent and the independent variables is 100%. This implies that a temperature change in this area is highly associated with NO_2, H_2S, Cl^-, SO_2, NH_3 SPM and CO. From the result, it could also be seen that the coefficient of NO_2 and SPM is negative showing that temperature changes in Umuahia will increase when the volume of NO_2 in the atmosphere reduces. The coefficients of H_2S, Cl^-, SO_2, NH_3 and CO are positive indicating a positive relationship between them and temperature. It therefore implies that when the volume of H_2S, Cl^-, SO_2, NH_3 and CO increases, the temperature of the area under study will also increase. In Eket, the result in Table 11 shows that the correlation between of the dependent variable of temperature and the independent variables of H_2S, Cl^-, SO_2, HCN, NH_3, SPM and CO is 1.00. The R^2 value of 100 indicates that degree of variance between the dependent and the independent variables is 100%. This implies that a temperature change in this area is highly associated with H_2S, Cl^-, SO_2, HCN, NH_3 SPM and CO. The coefficients of H_2S, Cl^-, SPM and CO are negative, indicating a negative relationship between them and temperature. The coefficient of SO_2, HCN and NH_3 are positive indicating that a positive relationship exists between their presence in air and the temperature changes in Eket. Increase in the volume of these substances in air will certainly increase the temperature of the area under study. In Ibeno, It could be observed from Table 11 that the R-value is 1.00. It shows that there exists a positive correlation between the dependent variable of temperature and the independent variables of NO_2, H_2S Cl^-, SO_2, SPM, HCN, CO. Also, the R^2 value of 1.00 revealed that, the percentage of variance of the dependent variable accounted for by the independent variables is 100%. It implies that temperature in Ibeno is 100% influenced by NO_2, H_2S, Cl^-, SO_2, SPM, HCN and CO. The coefficients of NO_2, SO_2 and H_2S are positive

Table 12. Model summary for wind speed.

Station	NO_2	H_2S	SO_2	HCN	SPM	Cl^-	CO	NH_3
Umudike	+	-	-	NE	-	+	-	+
Eket	NE	-	+	+	-	-	+	-
Ibeno	+	+	-	-	-	+	-	NE

R^2 = 1.00, R = 1.00, dependent variable: wind speed, NE = no effect.

Table 13. Model summary for rainfall.

Station	NO_2	H_2S	SO_2	HCN	SPM	Cl^-	CO	NH_3
Umudike	+	-	-	NE	-	-	+	+
Eket	NE	-	+	+	-	-	+	-
Ibeno	+	+	+	-	-	-	-	NE
Onna	NE	+	+	+	-	+	-	-
Esit Eket	NE	-	-	+	+	+	+	-

R^2 = 1.00, R = 1.00, Dependent variable: rainfall, NE = no effect.

indicating that there is a positive relationship between NO_2, SO_2, H_2S and temperature. It shows that when the volume of NO_2, SO_2 and H_2S in air increases the temperature of the study location will increase. The coefficient of Cl^-, SPM, HCN, CO, are negative showing an inverse relationship between them and temperature. In Table 11, the result in Onna shows that the R-value is 1.00. It shows that there exists a positive correlation between the dependent variable of temperature and the independent variables of H_2S Cl^-, SO_2 HCN, NH_3 SPM and CO. Also, the R^2 value of 1.00 revealed that, the percentage of variance of the dependent variable accounted for by the independent variable is 100%. It implies that a temperature change in Onna is 100% influenced by H_2S Cl^-, SO_2 HCN, NH_3 SPM and CO. The coefficients of H_2S, HCN and CO are positive indicating that there is a positive relationship between then and temperature. It shows that when the volume of H_2S, HCN and CO in air increases, temperature will increase. The coefficient of Cl^- SO_2, NH_3, SPM are negative showing that temperature will likely increase as their volume in air decreases. In Table 11, the result of Esit Eket revealed that the R-value is 1.00. This shows that there exists a positive correlation between the dependent variable of temperature and the independent variables of H_2S, SO_2, Cl^-, NH_3 HCN, SPM and CO. Also, the R^2 value of 1.00 revealed that, the percentage of variance of the dependent variable accounted for by the independent variable is 100%. It implies that temperature in Esit Eket is 100% caused by H_2S, SO_2, Cl^-, NH_3 HCN, SPM and CO. The coefficients of H_2S, Cl^-, NH_3 HCN and CO are negative indicating that there is a negative relationship between them and temperature in this area. It shows that when their volume of in air increases, the temperature of the area will decrease. The coefficient of SO_2 and SPM is positive, showing that temperatures will likely increase as their volume in air increases.

For humidity, the result in Table 10 for Umudike revealed that the correlation between of the dependent variable of humidity and the independent variables of H_2S, Cl^-, SO_2, HCN, SPM and CO is 1. This shows a strong positive correlation between the dependent variable and the independent variables. The R^2 value of 1.00 indicates that degree of variance between the dependent and the independent variable is 100%. The coefficients of NO_2, H_2S, SO_2, SPM and CO in this equation are positive, showing that there exist a positive relationship between them and humidity. It implies that when their volume increases, humidity will also increase. Other parameters have negative effect on humidity in Umudike as seen in Table 13. In Eket, the R coefficient of 1.00 shows that the correlation between the dependent variable of humidity and the impendent variables of H_2S, Cl^-, SO_2, HCN, NH_3, SPM and CO is one (1). This implies a strong positive relationship between the dependent variable and the independent variables. The R^2 coefficient of 1.00 revealed that proportion of variance between the dependent variable and the independent variable is 100%. It implies that humidity changes in the study are is highly caused by H_2S, Cl^-, SO_2, HCN, NH_3, SPM and CO. From the equation, it could be observed that the coefficient of H_2S Cl^-, SPM and CO is positive which imply that when their volume of air increases, the humidity of the area will certainly increase. The coefficient SO_2, NH_3, and HCN are all negative, indicating a negative relationship between them and humidity in the research area. In Ibeno, It could be observed from Table 10 that the R-value is 1.00. It shows that there exists a positive correlation between the dependent variable of humidity and the independent variables of NO_2, H_2S Cl^-, SO_2, SPM, HCN and CO. Also, the R^2 value of 1.00 revealed that, the percentage of variance of the dependent variable accounted for by the independent variable is 100%. It implies that humidity in Ibeno is 100% caused by NO_2 H_2S Cl^-, SO_2, SPM, HCN, CO. The coefficients of NO_2, H_2S and SO_2 are positive, indicating that there is a positive relationship between them and humidity. It shows that when the volume of NO_2, H_2S and SO_2 in air increases, the humidity will increase. The coefficient of HCN, SPM, CO and Cl^-, are negative showing an inverse relationship between them and humidity. In Onna, it could be observed that the R-value is 1.00. It shows that there exists a positive correlation between the dependent variable of humidity and the independent variables of H_2S, Cl^-, SO_2, HCN, NH_3, SPM and CO. Also, the R^2 value of 1.00 revealed that, the percentage of variance of the dependent variable accounted for by the independent variable is 100%. It implies that humidity in Onna is 100% influenced by H_2S, Cl^-, SO_2, HCN, NH_3 SPM and CO. The coefficients of H_2S, HCN, NH_3 and CO are negative indicating that there is a negative relationship between them and humidity in this study area. The coefficient of Cl^-, SO_2 and SPM are positive showing that humidity will likely increase as there is an increase in their volume in air. In Table 10, the result of Esit Eket revealed that the R-value is 1.00. This shows that there exists a positive correlation between the dependent variable of humidity and the independent variables of H_2S, Cl^-, SO_2, HCN, NH_3 SPM and CO. Also, the R^2 value of 1.00 revealed that, the percentage of variance of the dependent variable accounted for by the independent variable is 100%. The coefficient of H_2S, SO_2, NH_3 in this equation are negative showing that there exists a negative relationship between them and humidity in the research area. The coefficients of Cl^-, HCN, SPM and CO are positive showing that humidity will likely increase as their volume increases in the air.

From Table 12, it could be seen that our R value is 1.00 for wind speed in Umudike. This indicates that the correlation between the dependent variable of wind speed and the independent variables of NO_2, H_2S Cl^-, SO_2, NH_3, SPM and CO is 1.00. Also, the R^2 of 1.00 shows that the independent variables of NO_2, H_2S, Cl^-, SO_2, SPM, HCN and CO account for 100% of any variation in wind speed changes in the study area. The coefficients of NO_2, Cl^- and NH_3 are positive, this implies that wind speed in this area will increases as the volume of these compounds increases in air. The coefficient of SO_2, SPM, H_2S and CO are negative showing that wind speed of the area will increases as the volume of SO_2, SPM, Cl^- and CO decrease from atmosphere. In Eket, from Table 12, it could be seen that our R value is 1.00. This indicates that the correlation between the dependent variable of wind speed and the independent variables of H_2S, Cl^-, SO_2, HCN, NH_3, SPM, and CO is 1.00. Also the R^2 of 1.00 shows that the independent variables of H_2S, Cl^-, SO_2, SPM, HCN and CO account for 100% of any variation in wind speed changes in the study area. The coefficients of SO_2, HCN and CO are positive; this implies that wind speed in this area will increase as the volume of these compounds increases in air. The coefficient of H_2S, SPM, Cl^- and NH_3 are negative showing that wind speed of the area will increases as the volume of H_2S, SPM, Cl^- and NH_3 decrease from atmosphere. In Ibeno, from Table 12, it could be seen that our R value is 1.00. This indicates that the correlation between the dependent variable of wind speed and the independent variables of NO_2, H_2S Cl^-, SO_2, SPM, HCN and CO is 1.00. Also, the R^2 of 1.00 shows that the independent variables of NO_2, H_2S Cl^-, SO_2, SPM, HCN and CO account for 100% of any variation in wind speed changes in the study area. The coefficients of NO_2, H_2S and Cl are positive, this implies that wind speed in this area will increases as the volume of these compounds increases in air. The coefficient of SO_2, SPM, HCN and CO are negative showing that wind speed of the area will decreases as the volume of SO_2, SPM, HCN and CO increases in the atmosphere.

From Table 13, the result shows that the correlation between the dependent variable of rainfall and the independent variables of NO_2, H_2S, Cl^-, SO_2, NH_3, SPM and CO is 1.00 in Umudike. The R^2 value of 1.00 indicates that degree of variance between the dependent and the independent variable is 100%. This implies that the amount of rainfall in the area is seriously determined by the quantity of NO_2, H_2S, Cl^-, SO_2, NH_3, SPM and CO present in the atmosphere. From the result, it could also be seen that the coefficient of NO_2 is positive showing that as the volume of nitrogen dioxide (NO_2) increases in air, the probability that rainfall will increase is very high. Also, from Table 13, the coefficient of H_2S is negative revealing that rainfall in Umudike is negatively associated with the volume of H_2S present in the atmosphere. It therefore means that as the amount of H_2S increases in the atmosphere, the tendency for the rain to fall is low. Also, the coefficient of Cl^- in this equation is negative, indicating that, an inverse relationship exists between the presence of Cl^- in air and the amount of rainfall in the study area. It therefore implies that when the volume of Cl^- increases in the atmosphere, the rainfall of the area under study will decreases. The coefficient of SO_2 is negative showing a negative relationship between the presence of SO_2 in air and the rainfall in Umudike. It could also be seen from the equation that the coefficient of NH_3 is positive indicating a positive relationship between NH_3 and rainfall of the area under study. This shows that when the volume of NH_3 increases in air, the likely-hood for the area to experience rainfall reduces. The coefficient of SPM in this equation is negative, implying that there exist a negative relationship between SPM and rainfall. It shows that when the volume of SPM increases, the tendency for rain to fall in the area under study decreases. The last variable in this equation that affect rainfall is CO. The coefficient of CO in this equation is positive indicating a positive relationship between the presence of CO in air and rainfall. From the result, it could be seen that rainfall in the study area is highly associated with the amount the volume of CO present in air which means that as CO increases rainfall will also increase. In Table 13, the result in Eket revealed that the correlation between of the dependent variable rainfall and the independent variables of H_2S, Cl^-, SO_2, HCN, NH_3, SPM and CO is 1.00. The R^2 value of 1.00 indicates that degree of variance between the dependent and the independent variables is 100%. The result shows that the coefficient of H_2S, Cl^- and NH_3 is negative; this means that their increase does not cause rainfall in the study area. The coefficients of $SO_{2,}$ HCN and CO are positive, indicating that a positive relationship exists between them and the rainfall in Eket.

It could be observed from Table 13 that the R-value is 1.00 in Ibeno. It shows that there exists a positive correlation between the dependent variable of rainfall and the independent variables of NO_2, H_2S Cl^-, SO_2, SPM, HCN, CO. Also, the R^2 value of 1.00 revealed that, the percentage of variance of the dependent variable accounted for by the independent variable is 100%. The coefficient of NO_2, H_2S, SO_2 and Cl^- are positive indicating that there is a positive relationship between them and rainfall in Ibeno. It shows that when the volume of NO_2, H_2S, SO, and Cl^- in air increases, the probability that rain will fall in this area also increased. It implies that rainfall in Ibeno is 100% caused by H_2S Cl^-, SO_2 and NO_2. From Table 13, it could be observed that the R-value is 1.00 in Onna. It shows that there exists a positive correlation between the dependent variable of rainfall and the independent variables of H_2S Cl^-, SO_2 HCN, NH_3 SPM and CO. Also, the R^2 value of 1.00 revealed that, the percentage of variance of the dependent variable accounted for by the independent variable is 100%. It implies that rainfall in Onna is 100% influenced of by the present H_2S, Cl^-, SO_2 and HCN in air. The coefficient of $NH_{3,}$ SPM, CO, CO_2 in this equation is negative showing that there exists a negative relationship between them and rainfall in the research area. In Esit Eket, the result in Table 13 revealed that the R-value is 1.00. This shows that there exists a positive correlation between the dependent variable of rainfall and the independent variables of H_2S, $SO_{2,}$ Cl^-, HCN, NH_3, SPM and CO. Also, the R^2 value of 1.00 revealed that, the percentage of variance of the dependent variable accounted for by the independent variable is 100%. The coefficients of Cl-, HCN, SPM and CO are positive showing that rainfalls will likely increase as there is increases in its volume in air. It implies that rainfall in Esit Eket is 100% caused by Cl^-, HCN, SPM and CO. The coefficient of H_2S, SO2, NH3 are negative indicating that there is a negative relationship between them and rainfall. It shows that when their volume in air increases, it does not increase rainfall in this location.

Conclusion

Mean concentration of air parameters studied were below FEPA and USEPA National air quality standards with exception of carbon monoxide which exceeds the limit of 35 ppm in March at Ibeno. It was also established that a positive correlation exits between NO_2, H_2S, SO_2, SPM, chloride, carbon monoxide, and wind speed relative humidity, temperature and vapour pressure of the study locations. Chloride and nitrate also have a positive relation-ship with wind speed in some of the study locations.

Conflict of Interest

The authors did not declare any conflict of interest.

REFERENCES

Anderson I (2005). Niger River Basin: A Vision for Sustainable Development. The World Bank, pp: 131.

Abdul Raheem AMO, FA Adekola, IB Obioh (2009). Monitoring Of Sulfur Dioxide In The Guinea Savanna Zone Of Nigeria: Implications Of The Atmospheric Photochemistry. Bull. Chem. Soc. Ethiop. 2009, 23(3):001-008.

Ettouney RS, Zaki JG, El-Rifiai MA, Ettouney HM (2010), An Assessment of the Air Pollution Data from Two Monitoring Stations in Kuwait. Toxicol. Environ. Chem. 92(4):655-668.

Kalabokas PO, Viras LG, Repapis C (1999). “Analysis of the 11 – years record (1987 - 1997) of Air Pollution Measurements in Athens, Greece, Part I: Primary Air Pollutants”, Global Nest Journal. 1(3):157-167.

Okunola, OJ, Uzairu A, Gimba CE, Ndukwe GI (2012). Assessment of Gaseous Pollutant along High Traffic Roads in Kano, Nigeria. Int. J. Environ. Sust. 1(1):1-15.

Aliyu YA, Musa IJ, Youngu TT (2013). Appraisal of Sulphur Contaminants from Transportation in Urban Zaria, Nigeria. Academic Journal of Interdisciplinary Studies MCSER Publishing, Rome-Italy. 2(10):155-163.

Tawari CC, Abowei JFN (2012). Air Pollution in the Niger Delta Area of Nigeria. Int. J. Fish. Aquatic Sci. 1(2):94-117.

Mabahwi Nurul Ashikin, Oliver Ling Hoon Leh, Dasimah Omar (2014). Procedia - Social and Behavioral Sciences. 1- 5

Babatunde Saheed Bada1, Kofoworola Amudat Olatunde, Adeola Oluwajana (2013). Air quality assessment in the vicinity of cement company. Int. Res. J. Nat. Sci. 1(2):34-42, June 2013.