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Assessment of Changes in Air Quality in Wet Season: A Case Study of Eleme, Rivers State, Nigeria.

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Abstract
The assessment of changes in air quality was carried out to assess variation in the air quality status in the wet season in the study area by using the portable air quality equipment and this was done in-situ. The wet season results obtained around Eleme area showed that the mean concentrationof SO_2 was above permissible limits in the wet season; the mean concentration of NO_2 also exceeded the Federal Ministry of Environment (FMEnv) and National Ambient Air Quality Standards (NAAQS) limits.The mean value recorded for H_2S was 0.37±0.48ppm in the wet season; similarly, the mean value of VOCs was 3.45±2.84ppmin the wet season.The mean concentration of CO is within stipulated limits in the wet season. The mean value observed forammonia was2.6±1.92ppm; the mean value of methane was 1.27±1.82ppm. Furthermore, the wet season mean concentrations of TSP fall within both FMEnv and NAAQS limits. Also, mean concentrations of PM_{10}fallbelowNAAQS limit. Similarly, the wet season mean value of $PM_{2.5}$ is within the limit. These results revealed that some sampling points and air pollutants pose hazard while some other sampling point and air pollutants pose no risk to the residents in the wet season.

Keywords:*Air quality, Wet season, Assessment of air pollution.*

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I. Introduction

Change is a constant phenomenon in the universe. This change is not an exception in the environment which man dwells. The change in the environment simultaneously or invariably affects every environmental components in the ecosystem. This can be attributed to natural sources or anthropogenic sources/activities. Air quality is not an exception of this phenomenon called 'change'. Man's over exploitation of natural resources for his needs and for his greed aggravates the rapid changes in the environment and indeed, the air quality. Man poisons the air he breathes in for living ignorantly through his actions or inactions.

Scripturally, part of man's duty assigned by God was to dress and to keep the environment (Genesis 2:15) that is, man first assignment on earth was environmental management for his welfare, development and future generations. This beginning of development must not be impeded and the environment must not be degraded - sustainable development. But man deviated from the rules and regulations of how natural cycles of environment relate and brings introduction of pollutants into the same environment of which he is a receptor.Everitt (1992); Efe (2006); Akpan*et al.* (2014); Gobo *et al.* (2012) and Antai*et al.* (2016) reported in their studies on relatednegativeeffects of air pollutions on man and environment.These changes in air quality status research strictly adhered to Federal Ministry of Environment standard and international best practices.

Aim of the Study

The aim of this research is to assess changes in existing physical and chemical characteristic of the air quality and the level of concentrations of air pollutants in the study area.

II. Materials And Methods

Nature/Sources of Data

The field measured data collection was from the primary sources of seven (7) selected sampling points in the study area using portable air quality monitors (Aerocet-531S) to investigate particulate matter and (Aeroqual series 500) for the assessment of all the gaseous pollutants of the study area.

Method of Data Analysis
Mean concentration of air pollutants was computed using equation (1)

$$\overline{X} = \frac{\sum_{i=1}^{n} X_{meas,i}}{N} \quad (1)$$

Standard deviation was computed using equation (2)

$$s = \sqrt{\frac{\sum\left(X_{meas,i} - \overline{X}\right)}{N-1}} \quad (2)$$

Standard error estimate was determined using equation (3)

$$\sigma_{\overline{X}} = \frac{s}{\sqrt{N}} \quad (3)$$

Where, S is the standards deviation, $X_{meas,i}$ is the measured ith data point, $\overline{X}$ is the mean and N is the total number of data set.

Coefficient of variation of air pollutants
The coefficient of variation of each parameter was computed using Equation (4)

$$\%CV = \frac{S}{\bar{X}} = \frac{\sqrt{\frac{\sum\left(X_{meas,i} - \bar{X}\right)^2}{N-1}}}{\frac{\sum_{i=1}^{N} X_{meas,i}}{N}} \quad (4)$$

Computation of Exceedance Factor (EF)
A factor known as Exceedance Factor (CPCB, 2006) was used to determine pollutants compliance with national and international standards.
The Exceedance Factor (EF) was calculated using equation (5) as follows:

$$Excedence\ Factor\ (EF) = (100\frac{C_i}{C_{std}}) \quad (5)$$

Where $C_i$isthemeasured concentration of the ith parameter in the ambient air.

C_{std} is the regulatory standard recommended for the ith parameter.
For EF < 100, the parameter is said to be withing permissible limt, and for EF > 100, the parameter is said to exceed permissible limit. The EF for each pollutant was computed based on the Federal Ministry of Environment (FMEnv) stipulated permissible limit as contained in FEPA (1991) and National Ambient Air Quality Standards.

Table1: Sampling Points Key, Description of Sampling Points, Coordinate and Frequency of Monitoring

Sampling Point Code:	Description of Sampling Points	Coordinates	Frequency of Monitoring/Hourly
SP 1	Onne Roundabout by FLT and FOT Signboard	N 04^0 43`. 207'' E 007^{0}09'. 478''	Morning, Afternoon and Evening
SP 2	Notore Road by Notore Garden Camp, Onne	N 04^0 44'. 147'' E007^o 08'. 526''	Morning, Afternoon and Evening
SP 3	Onne (Trailer park) Junction by East-West Road	N 04^0 45'. 510'' E 007^0 09'. 516''	Morning, Afternoon and Evening
SP 4	Port Harcourt Refinery Junction by East-West Road, Alesa	N 04^0 47'. 066'' E 007^0 07'. 001''	Morning, Afternoon and Evening
SP 5	Agbonchia by Zina Motel Junction Eleme	N 04^{0}47'. 867'' E 007^0 07'. 358''	Morning, Afternoon and Evening
SP 6	Eleme Petrochemical (Ndorama gate) Aleto, Eleme	N 04^0 48'. 744'' E 007^0 05'. 842''	Morning, Afternoon and Evening
SP 7	Sandfilled Roundabout, Akpajo	N 04^0 49'. 402'' E 007^0 05'. 276''	Morning, Afternoon and Evening

III. Presentation Of Results

Concentrations of Sulphur Dioxide (SO_2) in Eleme Area

Results obtained in the wet season concentrations of sulphur dioxide ranged in value from 0.0ppm to 1.0ppm with mean deviation of 0.69±10.42ppm. Thewet season meanvalues exceeded both the Federal Ministry of Environment (FMEnv) and National Ambient Air Quality Standards (NAAQS) permissible limits of 0.1ppm and 0.14ppmrespectively. This might be as a result of industrial activities in Eleme area. Concentration levels of SO_2 in Eleme area in thewet season are shown in (Figure 1).

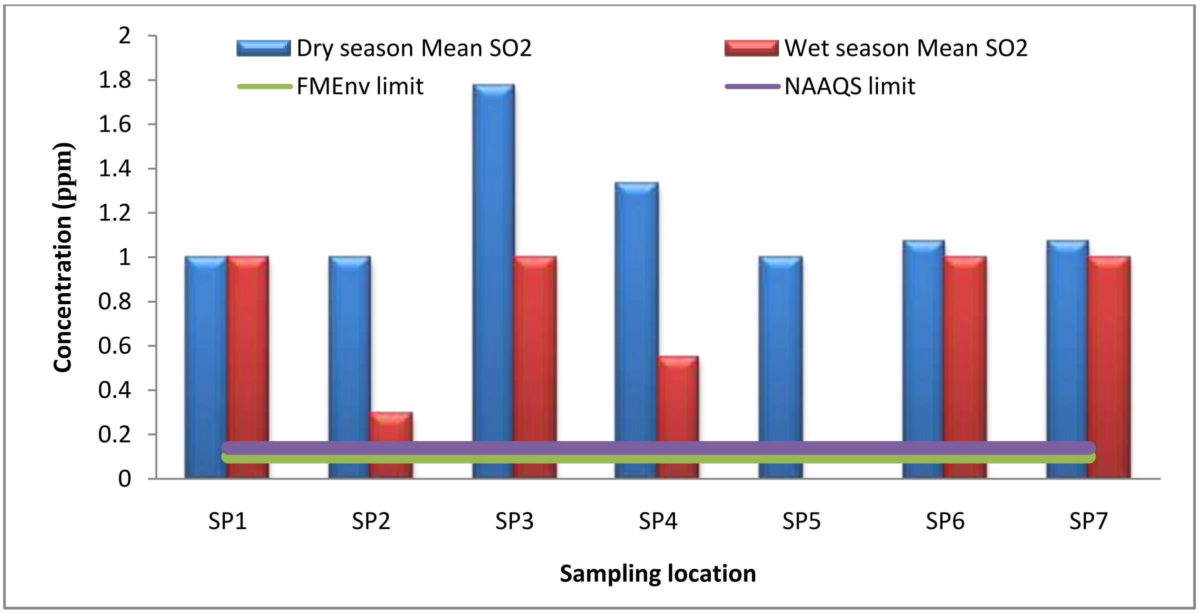

Figure 1: Concentrations of Sulphur Dioxide in Eleme Area

Concentrations of Nitrogen Dioxide (NO_2) in Eleme Area

Field results obtained in the wet season concentrations of nitrogen dioxide ranged in value from 0.0ppm to 1.0ppm with mean deviation of 0.57±10.53ppm. The mean valuesexceeded both the FMEnvand NAAQS limits in the wet season. This might be caused by industrial activities in Eleme area. Concentration levels of NO_2 in Eleme area in the wet season are shown in Figure 2.

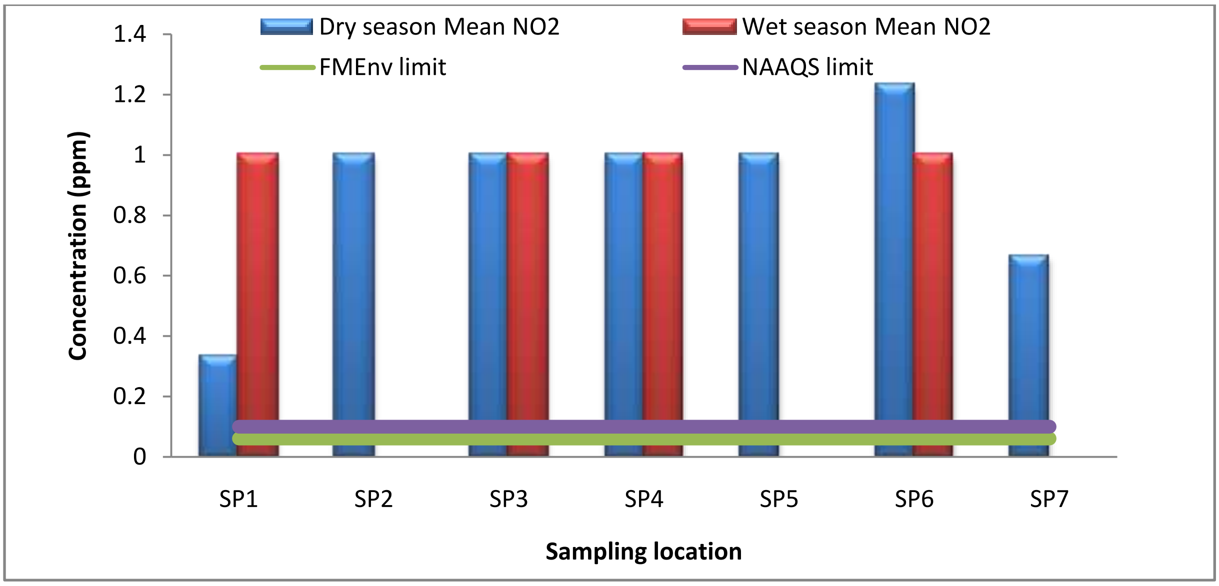

Figure 2: Concentrationsof Nitrogen Dioxide in Eleme Area

Concentrations of Hydrogen Sulphide(H_2S)in Eleme Area

The concentrations of H_2S obtained in Eleme areain wet season ranged from 0.0ppm to 1.0ppm with a mean concentrations of 0.37±0.48ppm (Figure 3).

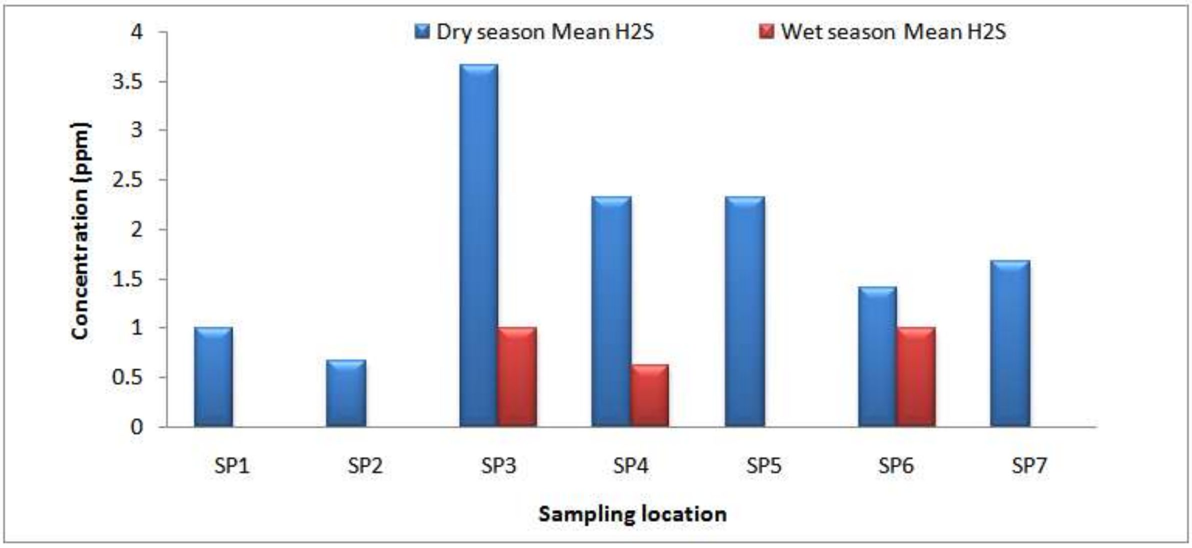

Figure 3: Concentrations of Hydrogen Sulphide in Eleme Area

Concentrations of Volatile Organic Compounds (VOCs)in Eleme Area

VOCs concentrations measured in the Eleme area in the wet season values ranged from 1.1ppm to 8.27ppm with a mean deviation of 3.45±2.84ppm. Concentration levels of VOCs obtained in Eleme area in the wet season are shown in Figure 4.

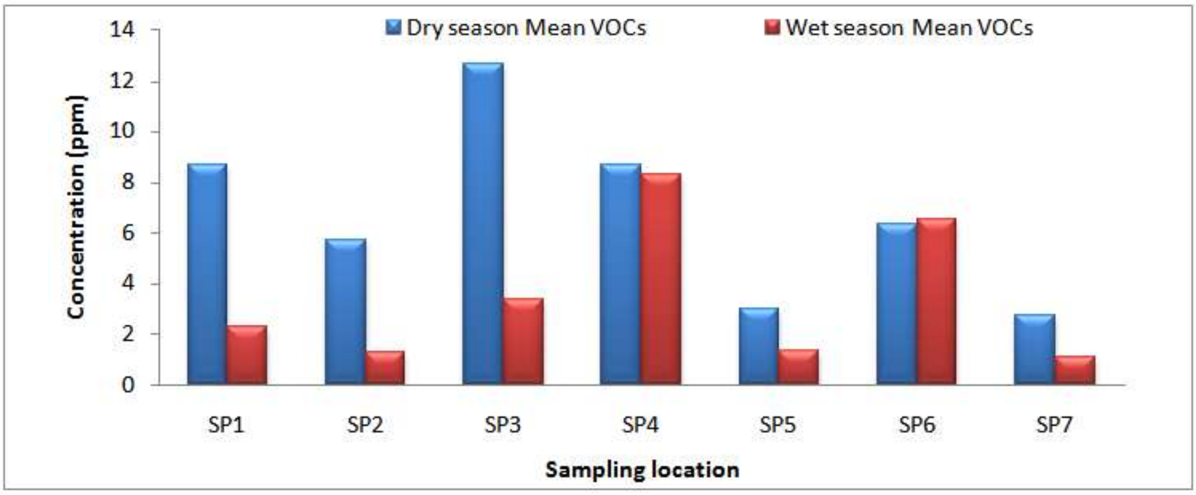

Figure 4: Volatile Organic Compounds Concentrations Measured in Eleme Area

Concentrations of Carbon Monoxide (CO) in Eleme Area

Thewet seasonvalues ranged from 1.7ppm to 17.8ppm with a mean deviation of 7.74±7.05ppm. The mean valuefalls belowboth the FMEnv and NAAQS limits in the wet season. Concentrations of CO measured in Eleme area in the wet season are shown in Figure 5.

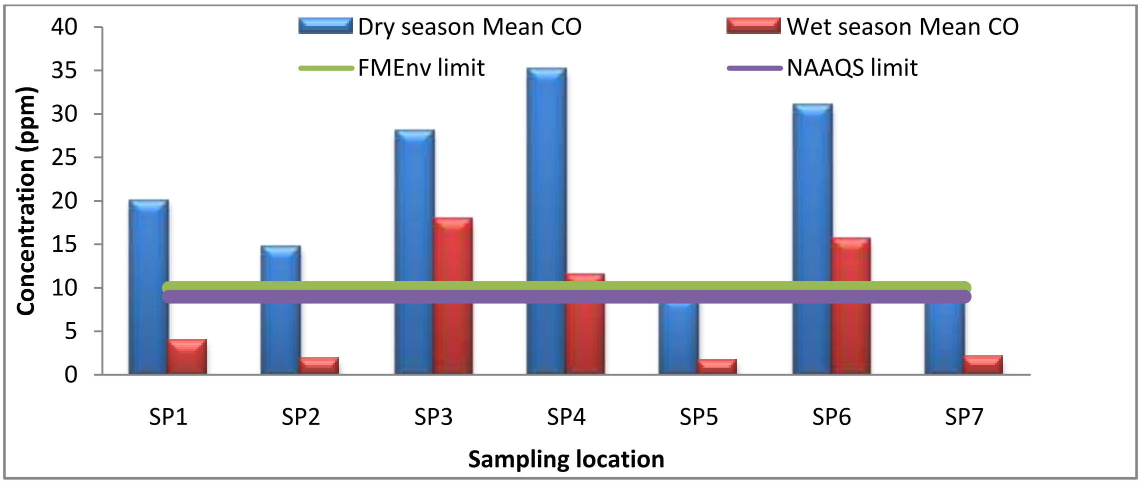

Figure 5: Concentrations of Carbon Monoxide in Eleme Area

Concentrations of Ammonia (NH_3) in Eleme Area

The concentrations of ammonia measured in the wet season ranged from 0.48ppm to 6.13ppm with a mean deviation of 2.6±1.92ppm. The wet season concentrations of NH_3 measured in the Eleme area are shown in Figure 6.

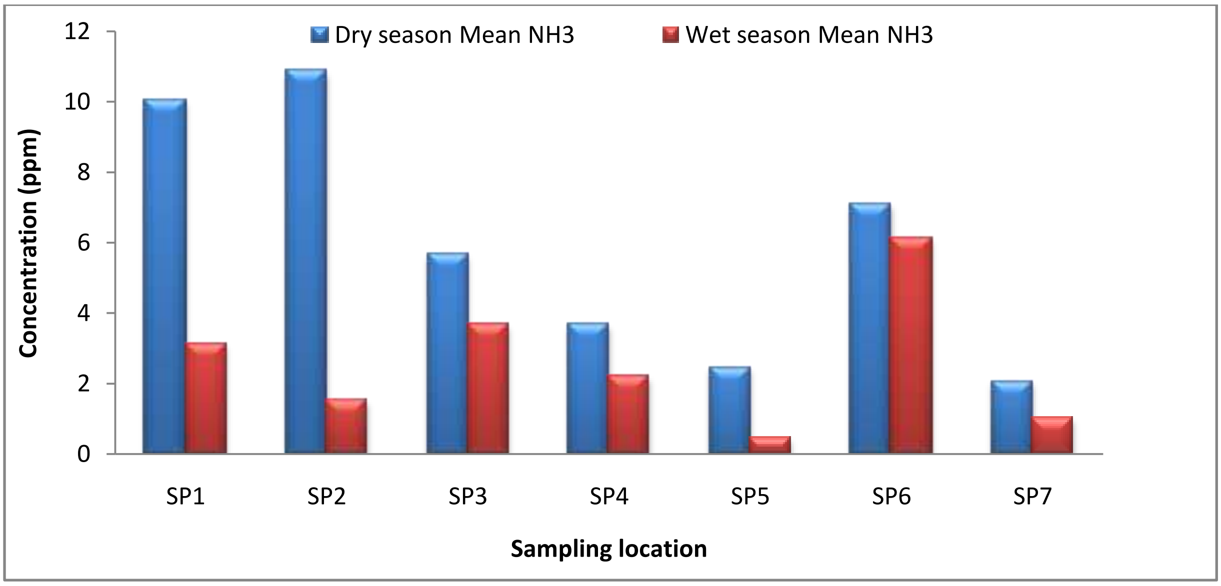

Figure 6: Concentrations of Ammonia in Eleme Area

Concentrations of Methane (CH_4) in Eleme Area

The wet season concentrations obtained in the area ranged from 0.0ppm to 4.97ppm with a mean deviation of 1.27±1.82ppm. Concentration levels of methane in Eleme area are shown in Figure 7.

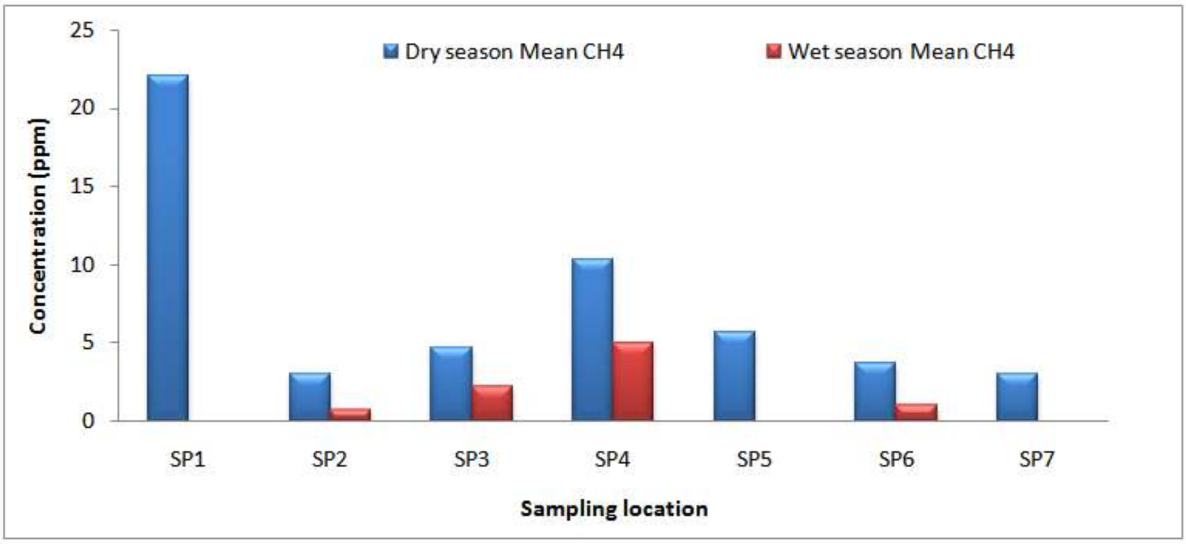

Figure 7: Concentration of Methane in Eleme Area

Concentrations of Total Suspended Particulate Matters (TSP) in Eleme Area

Concentrations of TSP obtained in the wet season values obtained in the area ranged from 25.5μg/m^3 to 69.2μg/m^3 with a mean deviation of 51.01±15.23μg/m^3. Thewet season mean value is well below bothFMEnv and NAAQS limits. Concentrations of TSPmeasured in the area during field survey are shown in Figure 8.

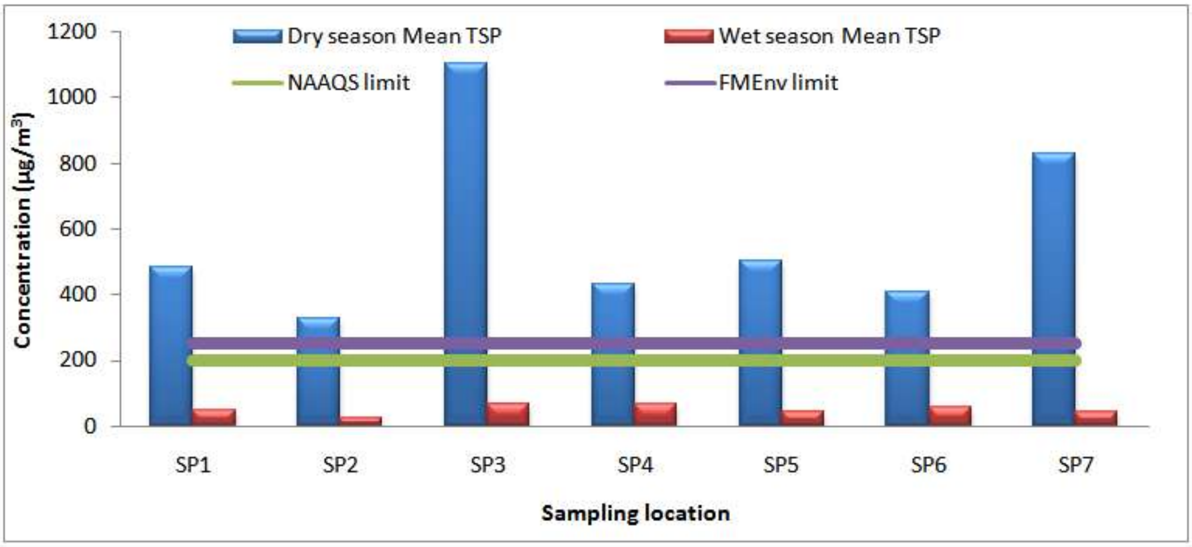

Figure 8: Concentration of Total Suspended Particulate Matter in Eleme Area

Concentrations of PM_{10} Particulate Matter in Eleme Area

The concentrations of PM_{10}measured in the wet season values ranged from 22.7µg/m^3 to 62.53µg/m^3 with a mean deviation of 45.51±13.49µg/m^3. Thewet season mean value falls below the NAAQS limit of 150µg/m^3. The concentrations of PM_{10} measured during field monitoring are shown in Figure 9.

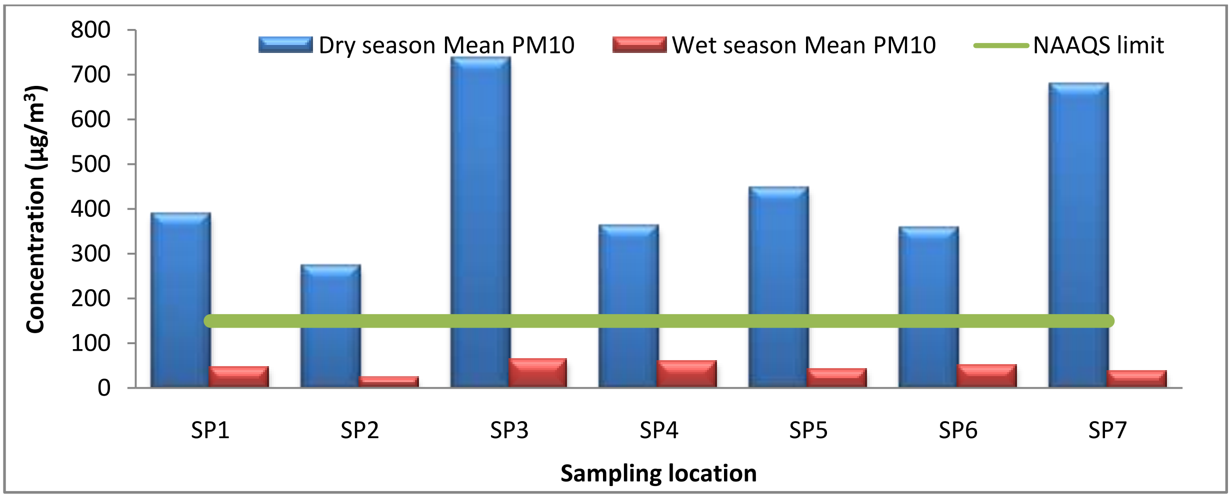

Figure 9: Concentrations of PM_{10}Particulate Matter in Eleme Area

Concentrations of $PM_{2.5}$ Particulate Matter in Eleme Area

The wet season concentrations of $PM_{2.5}$values ranged from 18.73µg/m^3 to 30.47µg/m^3 with a mean deviation of 25.66±9.35µg/m^3. The mean concentration of $PM_{2.5}$ measured in the wet season is below NAAQS limit of 35µg/m^3. The concentrations of $PM_{2.5}$ measured during field survey are shown in Figure 10.

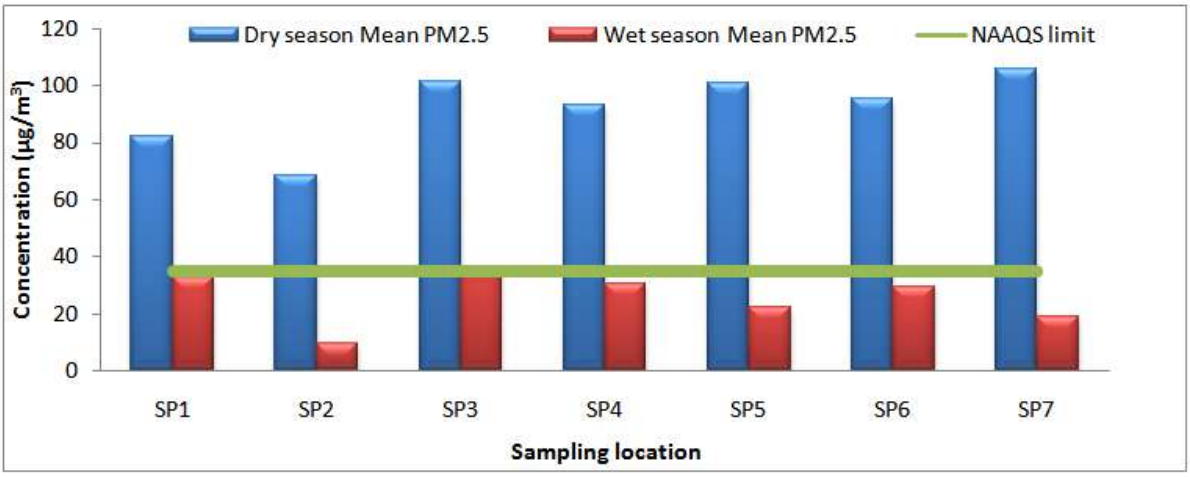

Figure 10: Concentration of $PM_{2.5}$ Particulate Matter in Eleme Area

IV. Interpretation And Discussion

Data Analysis of Air Quality inEleme Area

Computed coefficients of variations indicate that TSP, PM_{10} and $PM_{2.5}$ have low dispersion rate, while CH_4, H_2S, NO_2, CO, VOCs and NH_3 have high dispersion rates in the wet season.

The exceedance factor (EF) for each criteria pollutant in the area was calculated using the measured value of the i^{th} parameter and the NAAQS regulatory permissible standard value. Exceedance factor less than 100 ($EF < 100$) is below prescribed limit, while exceedance factor greater than 100 ($EF > 100$) exceeds prescribed limit. Computed exceedance factors in the wet season indicated low mean concentrations of TSP and PM_{10}, and moderate mean concentrations of $PM_{2.5}$ and CO; while $SO_2$and NO_2have very high mean concentrations. This implies that TSP and PM_{10} pose no immediate hazard to human health; $PM_{2.5}$ and COmay cause mild risk to human health; while SO_2 and NO_2 pose greater risk to public health in the wet season and people with respiratory disease such as asthma might be at greater risk.

MODELING THE RELATIONSHIP BETWEEN AIR POLLUTANTS AND METEOROLOGICAL PARAMETERS IN THE WET SEASON

A multiple linear regressions modeling was carried out to determine the influence of meteorological parameters on air pollutants in the wet season. Stepwise regression linear models were derived to establish the relationship between each pollutant and each meteorological parameter as presented in Table 2. While the multiple linear regressions modelsderived for each pollutant using all the meteorological parameters as presented in Equations (6).

(i) Variation of Methane (CH_4) with Meteorological Parameters in the Wet Season

The linear models (shown in Table 2) derived from the stepwise regression of CH_4 with each meteorological parameter indicated that the linear correlation between concentrations of $CH_4$and wind speed is highly significant at 0.05 confidence level ($P < 0.05$). The results (Figure 11 (a-e)) indicated that CH_4 concentrations correlated positively with wind speed and relative humidity with coefficient of determinations (R^2) of 0.022 and 0.00026 respectively and also varied negatively with wind direction, temperature and air pressure with coefficient of determinations of 0.00075, 0.0034 and 0.0048 respectively. These results revealed that wind speed accounted for 2.2%, wind direction accounted for 0.075%, relative humidity accounted for 0.026%, and temperature accounted for 0.34%, while air pressure accounted for 0.48% of the total variation of CH_4 concentrations in the wet season.

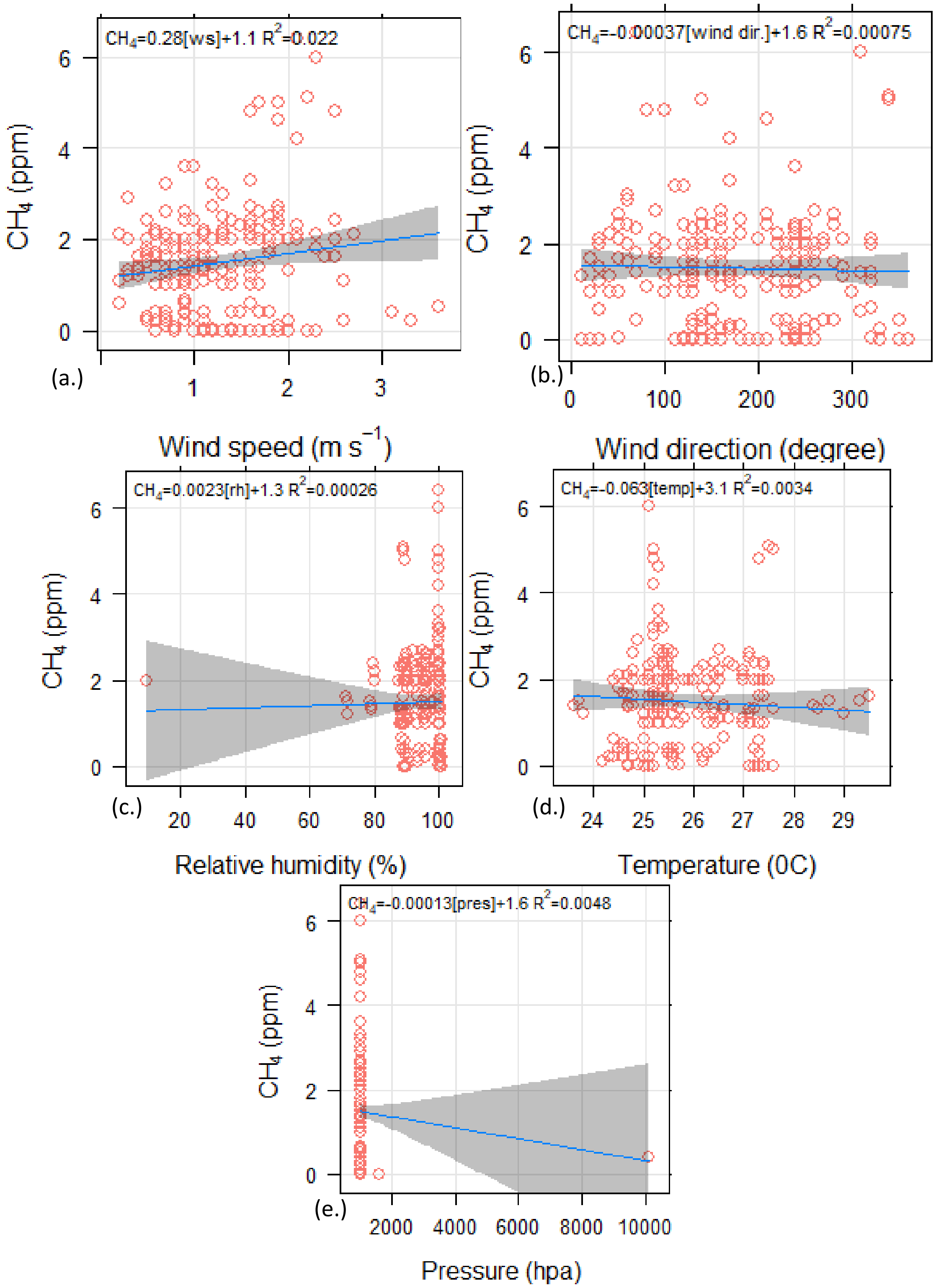

Figure 11 (a-e): Relationship between Predicted CH_4 and Meteorological Parameters in the Wet Season

Table 2:Stepwise Linear Models for Wet Season CH4

Pollutant	Stepwise Regression Linear Models	R^2	t-statistic	Sig. (2-tailed)
CH_4	= 1.1 + 0.28*Wsp	0.022	2.123	0.035*
	= 1.6 – 0.00037*Wd	0.00017	-0.116	0.908
	= 1.3 + 0.0023*Rh	0.00026	-0.686	0.493
	= 3.1 - 0.063*Temp	0.0034	-0.803	0.423
	= 1.6 – 0.00013*Pres	0.0048	-1.108	0.269

*Correlation is significant at the 0.05 confidence level (2-tailed)

A multiple linear regression model was developed using the combination of all the meteorological parameters as predictor variables and a model for the prediction of concentrations of CH_4 in the wet season was derived as shown in Equation (6). The derived Equation (6) was used to predict the concentrations of CH_4 in the study area in the wet season.

$$\mathbf{CH_4 = 4.079 + 0.280*Wsp + 0.0*Wd - 0.008*Rh - 0.077*Temp + 0.0*Pres} \quad (6)$$

Table 3: Analysis of Variance (ANOVA) for Wet Season CH_4 Prediction Model

Model	SSE (ppm)	df	MSE (ppm)	RMSE (ppm)	F	Sig.
Regression Error (SS_M)	8.943	5	1.789	1.338	1.311	0.261^b
Residual Error (SS_R)	282.408	207	1.364	1.168		
Total Error (SS_T)	291.351	212				

The mean square error (MSE) and the root mean square error of the model were computed to be1.789ppm and 1.338ppm respectively. The model sum of squares error (SS_M), residual sum of squares error (SS_R) and total sum of squares error (SS_T) were computed to be8.943ppm,282.408ppm and291.351ppm respectively as shown in Table 3. The result (Table 3) showed that meteorological parameters did not significantly influence the concentrations of CH_4 in the area (P-value <0.05). The goodness of fit (Figure 12) between predicted and measured values indicated a poor linear relationship between concentrations of CH_4 and meteorological parameters with a coefficient of determination (R^2) of 0.014. This implies that meteorological parameters explained or accounted for only 1.4% of the total variation of CH_4 concentrations in the wet season. The goodness of fit between predicted and measured concentrations of CH_4 is shown in Figure 12 while the predicted values are plotted against measured values as shown in Figure 13.

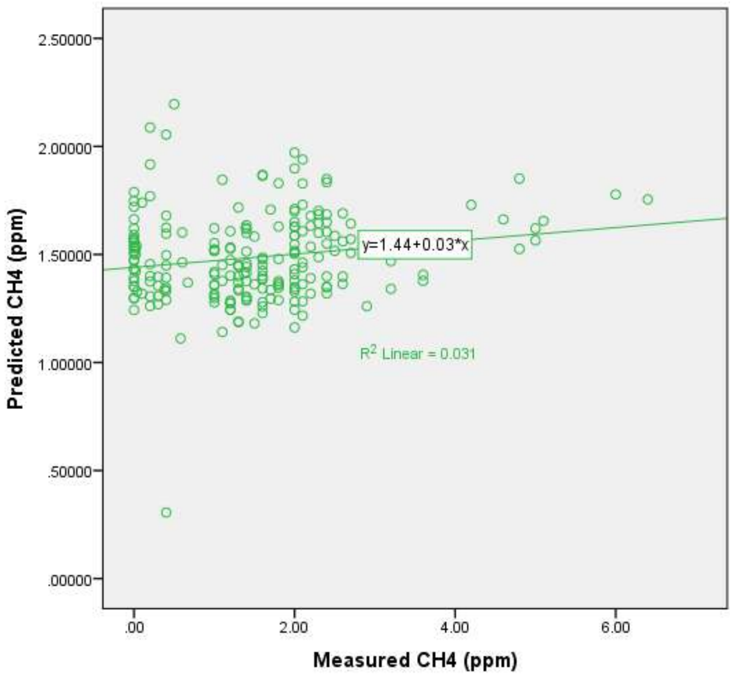

Figure 12: Best fit of Predicted CH_4 and Measured CH_4 in the Wet Season

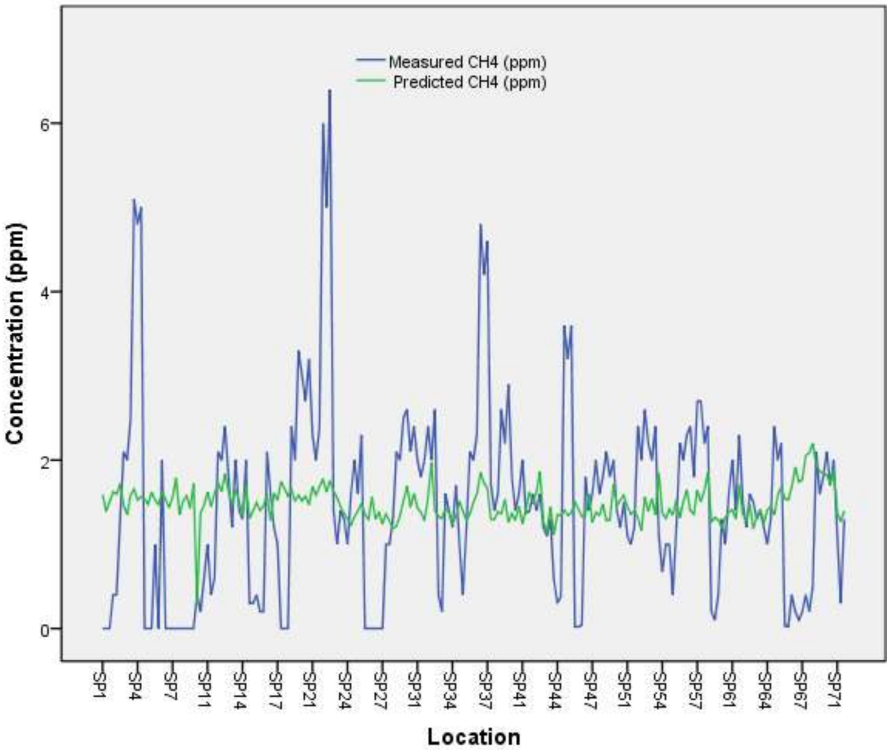

Figure 13: Predicted CH_4 versus Measured CH_4 in the Wet Season

(ii) Assessment of pollution

Computed pollutant standards indices (PSI) showed high values of SO_2, NO_2 and $PM_{2.5}$ (Table 4). This implies that SO_2, NO_2 and $PM_{2.5}$ are the main air pollutants prevailing in the Eleme area in the wet season**.**

The air quality indices computed in the wet season in Eleme area (Table 4) indicated good air quality at station SP5 (between 0 – 50), and moderate air quality (51 – 100) at station SP2 (Table 4). This indicated that station SP5 has good and satisfactory air quality with minor or no health risk, while air quality at station SP2 is acceptable; however, SO_2 and $PM_{2.5}$ pose some health concern for a very small number of sensitive people. Similarly, stations SP1 and SP4 showed unhealthy air quality (151 – 200), while stations SP3 and SP6 showed very unhealthy air quality (2001 – 300). This indicated that members of sensitive groups in stations SP1 and SP4 may experience more serious health effects, while there will be widespread effects among the general population and more severe effects in members of sensitive groups at stations SP3 and SP6. Station SP7 showed unhealthy air quality for sensitive groups (101 – 150), this may affect the health sensitive groups but may not affect the general public.

Table 4: Wet Season Pollutant Standard Index and Air Quality Index in Eleme area

Sampling Points	SO_2 PSI	NO_2 PSI	CO PSI	PM_{10} PSI	$PM_{2.5}$ PSI	AQI	AQI Rating
SP1	499.5	266.5	45.5	45.6	74.1	186.2	Unhealthy
SP2	190.6	0.0	19.5	22.7	39.0	54.4	Moderate
SP3	499.5	266.5	219.9	56.3	78.3	224.1	Very Unhealthy
SP4	280.0	266.5	145.3	54.2	71.5	163.5	Unhealthy
SP5	0.0	0.0	19.1	41.1	62.2	24.5	Good
SP6	499.5	266.5	205.1	50.5	70.5	218.4	Very Unhealthy
SP7	499.5	0.0	22.1	37.3	57.8	123.4	Unhealthy for Sensitive Groups

V. Conclusion

Wet season air quality condition of Eleme area indicated good, moderate, unhealthy and very unhealthy air quality status depending on the sampling point.Unhealthy and very unhealthy air quality may pose widespread effects among the general public and more severe effects in members of sensitive groups.

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