IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 14, Issue 4Ser. IV (April. 2020), PP 23-30
www.iosrjournals.org

Seasonal Investigation of Meteorological Variables Effects on Air Pollution in Eleme, Rivers State, Nigeria.

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Abstract: *This study was conducted to assess the meteorological parameters and their influence on the air pollutants in the study area using portable handheld meters. The level of air pollutant concentration depend not only on the quantities that are emitted from air pollution sources but also on the ability of the atmosphere to either absorb or disperse these emissions. The research showed that meteorological parameters had significant effects on air pollutants and there was also poor linear relationship on the air pollutants. Geographical and meteorological conditions of the study area could also influence some local background concentration of air pollutants since there is a relationship between air pollution and meteorological variables.In view of this, therefore, atmospheric pollutant conditions most often are subjected to spatio-temporal variations causing the air pollution pattern to change with space and time due to changes in meteorological and topographical conditions. The aim of the study was to assess existing meteorological variables as they influence the air quality status in the study area.*

Keywords:_Meteorological variables, Air pollution, Effects, Seasonal investigation._

Date of Submission: 13-04-2020 Date of Acceptance: 28-04-2020

I. Introduction

The absence of proactive environmental laws/regulations and ineffective enforcement of the existing laws and regulations create a big gap in air quality management (Ahove, 2006; Olowoporoku, 2011). Several studies have reported that residents of refinery areas, commercial squares, traffic junctions and residential areas which are densely populated suffered adverse effect of PM_{10} and associated high rate of respiratory diseases in most cities in Nigeria (Okecha, 2000; Efe, 2005 and 2006; Gobo *et al.,* 2012; Kochubovski and Kendrovski, 2012; Antai*et al.,* 2016).

Existence of man with respect to sustainable development society requires proper management and preservation of the environment through adequate knowledge of the changes in the air quality status of the environment and proposed mitigation measures (Bhatia, 2011).This is hinged on space variation of sources as well as atmospheric gradients which most often results in the diffusion and transportation of the pollutants to areas outside the source of the air pollution. Atmospheric dynamics which are generally controlled by meteorological factors (including temperature, air pressure, humidity, wind speed and direction, etc.) remarkably influence the tendency for the release of atmospheric toxins to the environment.

II. Materials And Methods

Nature/Sources of Data

Seven (7) selected sampling points were measured during data collectionfrom the primary sources in the study area to assess the meteorological parameters.

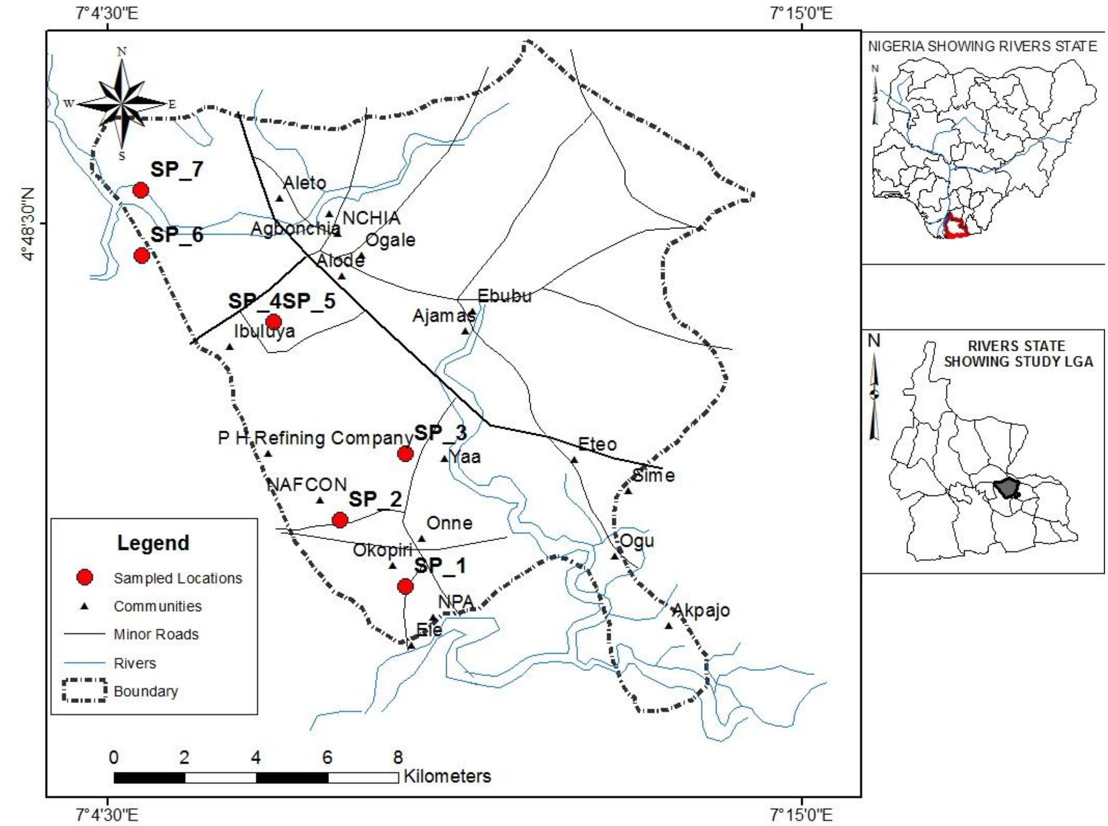


Figure 1: Eleme showing Sampling Points of the Study Area

Field meteorological parameters measured

i. Ambient temperature
ii. Air pressure
iii. Relative humidity
iv. Wind speed
v. Wind direction

Methods of Data Collection and Instrumentation

Sampling Equipment

The sampling equipment used were portable digital handheld meters to assess air pollutants and meteorological parameters:

i. The GPSmap Model 76Cx Garmin Global Positioning Systems was used to determine geo-references of the sampling points.
ii. The Kestrel 4500NV pocket weather tracker was used for assessment of meteorological data of the study area.
iii. Mass Particle Counter (Aerocet-531S) was used to investigate particulate matter

The Aerocet 531S is a full-featured, completely portable, battery operated handheld mass monitor or particle counter. Using a unique mass conversion, the Aerocet 531S particle counts from eight size ranges which are converted to mass using a proprietary algorithm for typical-density aerosols. Accommodation for special particulate with different densities is provided through user-programmable “k-factors”. Aerocet 531S counts individual particles using scattered laser light and calculates the equivalent mass concentration using a proprietary algorithm.

The Aerocet 531S simultaneously measures 6 mass concentration ranges (PM_1, $PM_{2.5}$, PM_4, PM_7, PM_{10} and TSP) displayed in mass mode; as well as five popular cumulative particles size (>0.3, 0.5, 1.0, 5.0 and 10.0) microns in count mode. It has sensitivity of high/low (0.3μm = high, 0.5μm = low), mass concentration units in $\mu g/m^3$, mass concentration precision is $0.1\mu g/m^3$, sample time in 1 minute, hold time unit in seconds and contrast adjust software.

The Aerocet 531S counts particles sizes in 8 different size ranges then uses a proprietary algorithm to convert count data to mass measurements $(\mu g/m^3)$. Fundamentally, the aerocet 531S calculates a volume for each detected particle then assigns a standard density for the conversion. The concentration of the particulate is determined by dividing the mass of the SPM by the volume of air sampled (WHO, 1976). The standard density value is augmented by the K-factor setting to improve measurement accuracy. The aerocet 531S provides a separate K-factor setting for each measurement range (PM_1, $PM_{2.5}$, PM_4, PM_7, PM_{10} and TSP). These K-factors can be modified with comet software or with the SK serial port command. K-factor values should be empirically derived via comparison with a reference unit. If a reference unit is unavailable, the recommended K-factor setting is 3.0

This unit provides particle counts or mass PM measurements as stored data logged values, rent-time networked data, or printed results. This instrument can store up to 6,257 sample events including data from the optional ambient temperature (AT)/relative humidity (RH) probe (PNG 3120). Sample history events can be viewed on the LCD display, printed on the optional printer (PNG 3115) and download to a computer via USB or RS232.

III. Presentation Of Results

METEOROLOGY RESULTS

Ambient Temperature Levels in Eleme Area

Mean Ambient temperature measured in the dry season in Eleme area ranged from 30.1^{0}C to 31.0^{0}C with a mean deviation of 30.54±0.36^{0}C; while the mean ambient temperature measured in the wet season ranged from 25.7^{0}C to 27.5^{0}C with a mean deviation of 27.06±0.6^{0}C. Temperature levels measured in the dry season were higher than that obtained in the wet seasons (Figure 2).

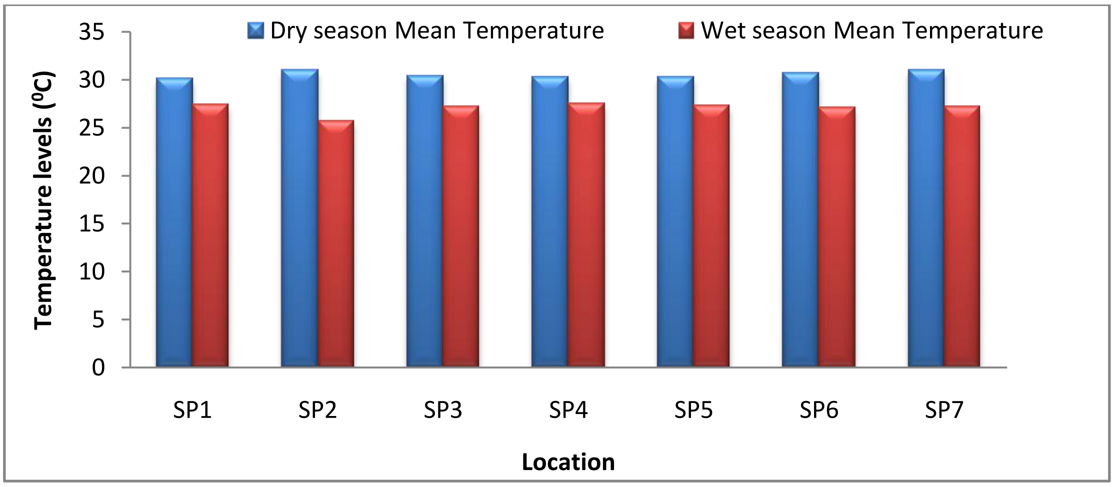


Figure 2: Mean Ambient Temperature Levels Measured in Eleme Area

Relative Humidity Levels in Eleme Area

Levels of mean relative humidity recorded around Eleme area in the dry season ranged from 52.4% to 71.4% with a mean deviation of 59.31±6.86%; while the mean relative humidity measure in the wet season in the area ranged from 89.2% to 95.8% with a mean deviation of 90.5±2.35% (Figure 3). Low values of relative humidity were recorded in the dry season because of the dry nature of the Harmattan haze during this period. Conversely, high values of relative humidity were recorded in wet season due to heavy downpour that characterized this period.

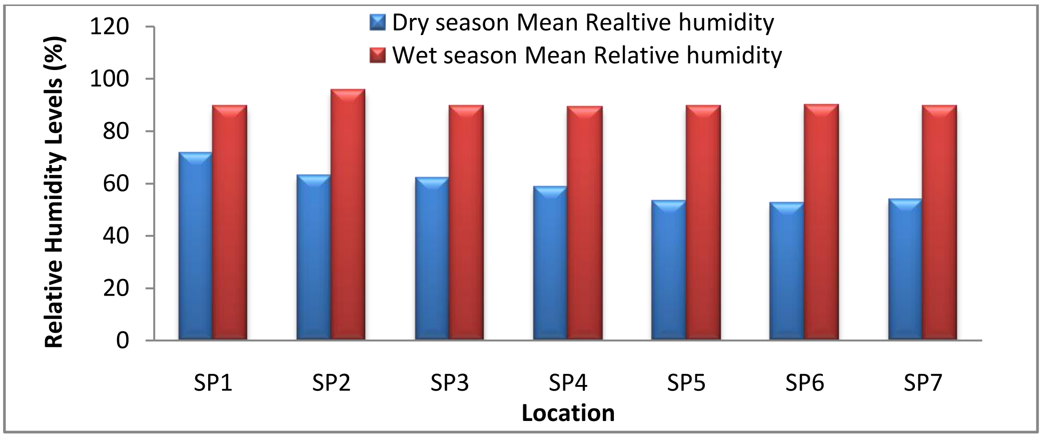


Figure 3: Mean Relative Humidity Levels Measured in Eleme Area

Wind Speed Levels in Eleme Area

Mean wind speed measured in the dry season period in Eleme area ranged from 0.9m/s to 2.1m/s with a mean deviation of 1.36±0.49m/s; while wet season mean wind speed recorded in the area ranged from 1.4m/s to 1.9m/s with a mean deviation of 1.61±0.17m/s (Figure 4).

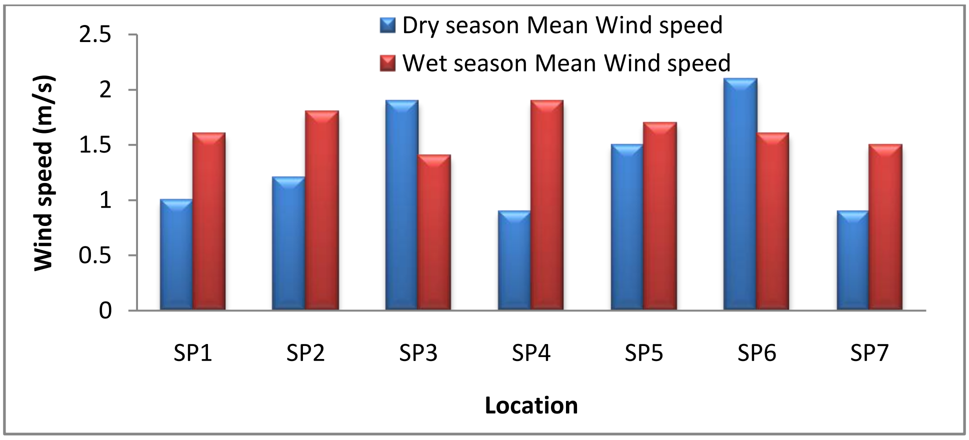


Figure 4: Mean Wind Speed Levels Measured in Eleme Area

Air Pressure Levels in Eleme Area

Levels of Mean air pressure measured in the dry season period in Eleme area ranged from 1004.5hpa to 1009.1hpa with a mean deviation of 1007.0±1.67hpa; while wet season mean air pressure recorded in the area ranged from 1011.0hpa to 1011.4hpa with a mean deviation of 1011.19±0.13hpa (Figure 5).

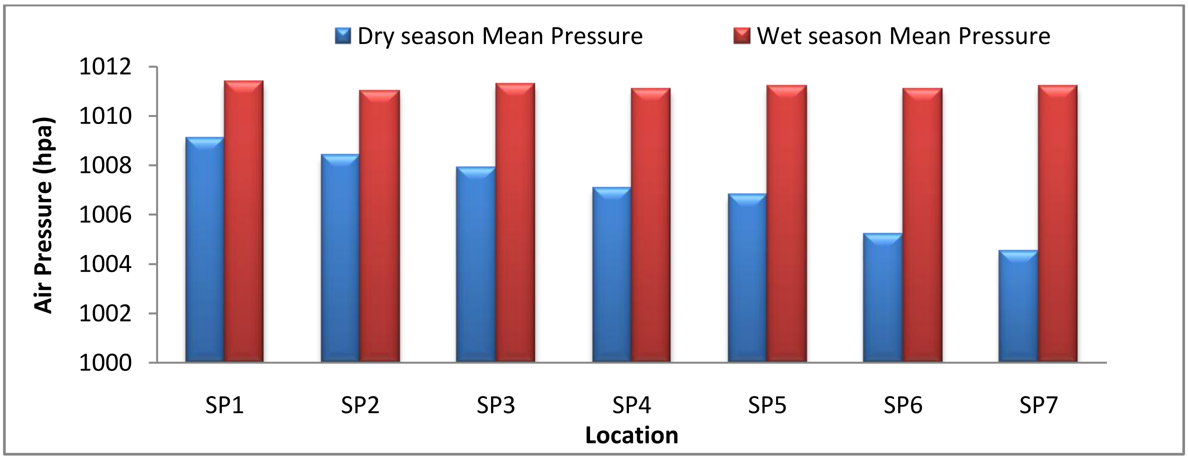


Figure 5: Mean Air Pressure Levels Measured in Eleme Area

IV. Discussion

Variation of PM_{10} Particulate Matter with Meteorological Parameters in the Dry Season

The results (shown in Figures6(a-e)) indicated that concentrations of PM_{10} correlated significantly with relative humidity and air pressure, and positively increases with wind direction, temperature and air pressure. The stepwise regression linear models (shown in Table 1) indicate that the linear relationships between PM_{10} and wind speed, wind direction and temperature are not significant at 0.05 confidence level. However, the relationship between air pressure and concentrations of PM_{10} particulate matter is highly significant at 0.05 confidence level for a 2-tail test with a coefficient of determination (R^2) of 0.011. This implies that though PM_{10} varies significantly with air pressure, only a fraction of 1.1% of the variation can be explained. Also, wind speed accounted for 0.47%, wind direction accounted for 0.9%, relative humidity accounted for 2.2% and temperature accounted for 0.85% of the total variation in the dry season period.

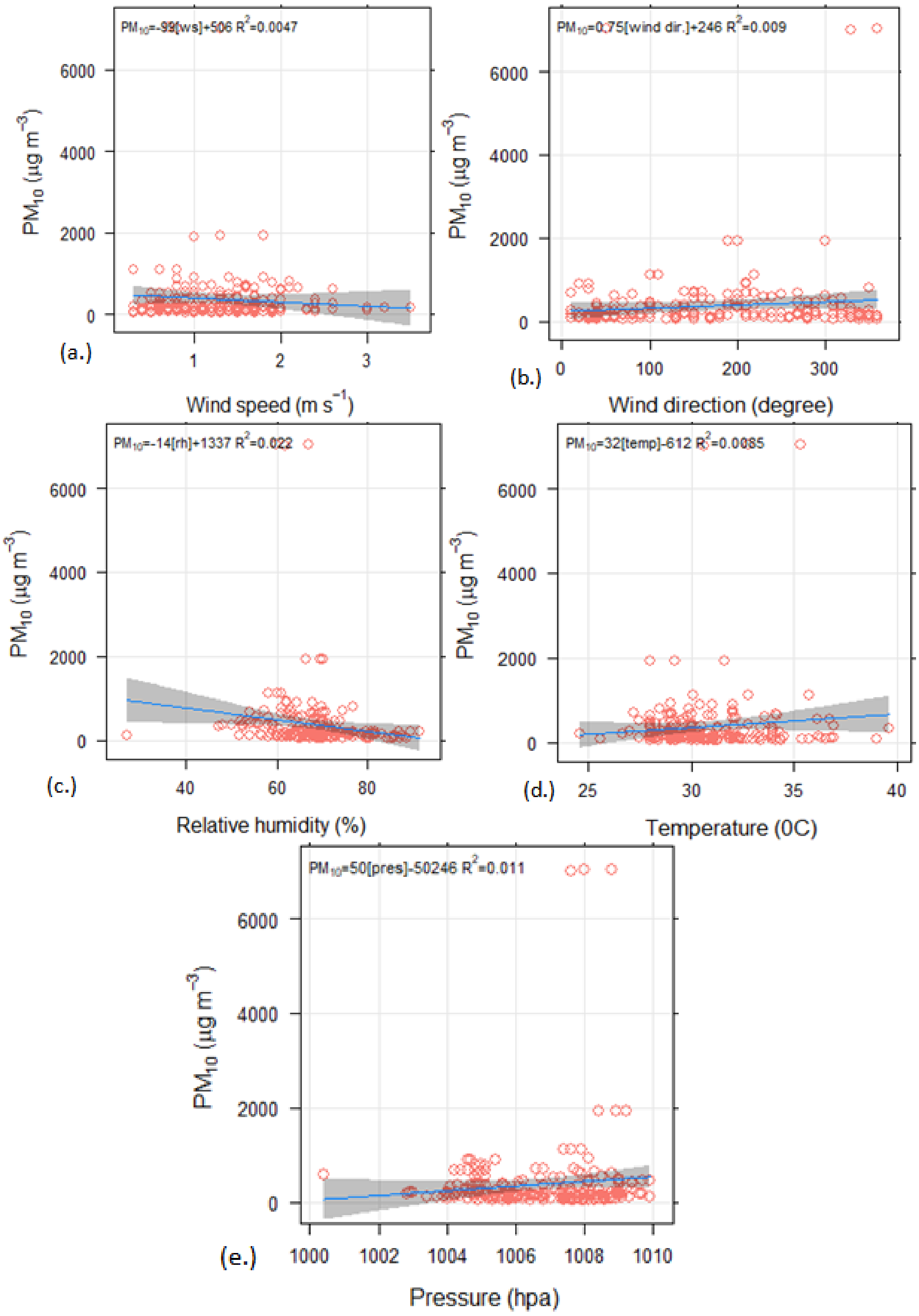


Figure 6 (a-e): Relationship between Predicted PM_{10} and Meteorological Parameters inthe Dry Season

Table 1:Stepwise Linear Models for PM_{10} in the Dry

Pollutant	Model	R^2	t-statistic	Sig. (2-tailed)
PM_{10}	= 506 – 99*Wsp	0.0047	- 1.008	0.315
	= 246 + 0.75*Wd	0.009	1.774	0.078
	= 1337 – 14*Rh	0.022	- 2.233	0.027*
	= - 612 + 32*Temp	0.0085	0.284	0.777
	= -50246 + 50*Pres	0.011	2.356	0.019*

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

A multiple linear regression model for the prediction of PM_{10} was developed combining all the meteorological parameters as predictor variables that affect PM_{10} concentrations. The following predictive model for PM_{10} particulate was thus derived Equation (1). The derived Equation (1) was used to predict the concentrations of PM_{10} in the study area in the dry season.

$$PM_{10} = -80299.164 - 100.963*Wsp + 0.959*Wd - 16.719*Rh + 7.625*Temp + 81.010*Pres \quad (1)$$

Table 2: Analysis of Variance (ANOVA) for Dry Season PM_{10} Prediction Model

Model	SSE (µg/m³)	df	MSE (µg/m³)	RMSE (µg/m³)	F	Sig.
Regression (SS_M)	9731477.447	5	1946295.489	1395.097	2.796	.018*
Residual (SS_R)	144085510.746	207	696065.269			
Total (SS_T)	153816988.193	212				

*Significant at the 0.05 level (2-tailed).

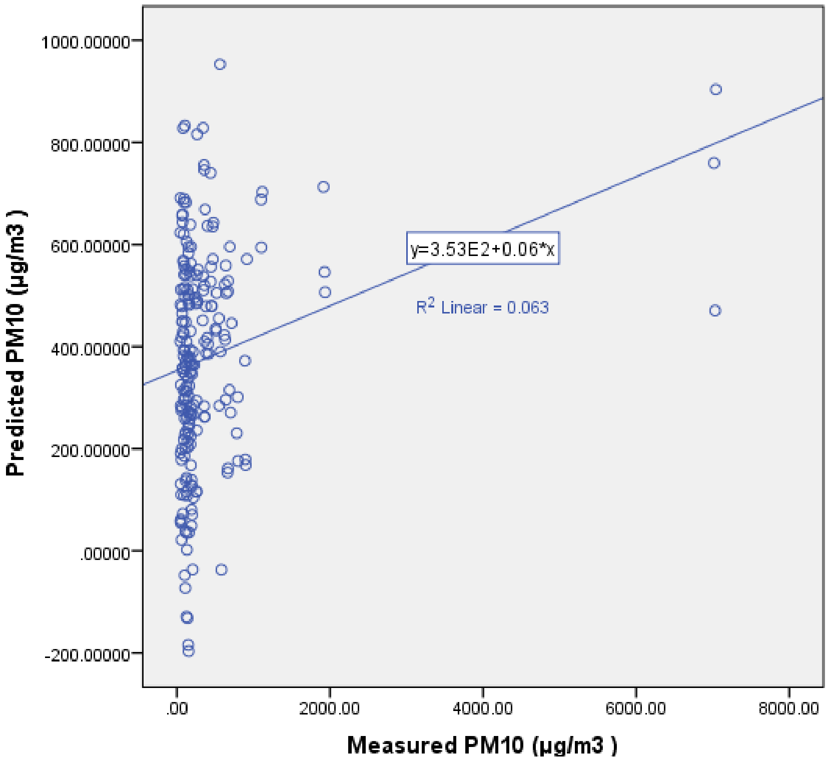


Figure 7: Relationship between Predicted PM_{10} and Measured PM_{10}in the Dry Season

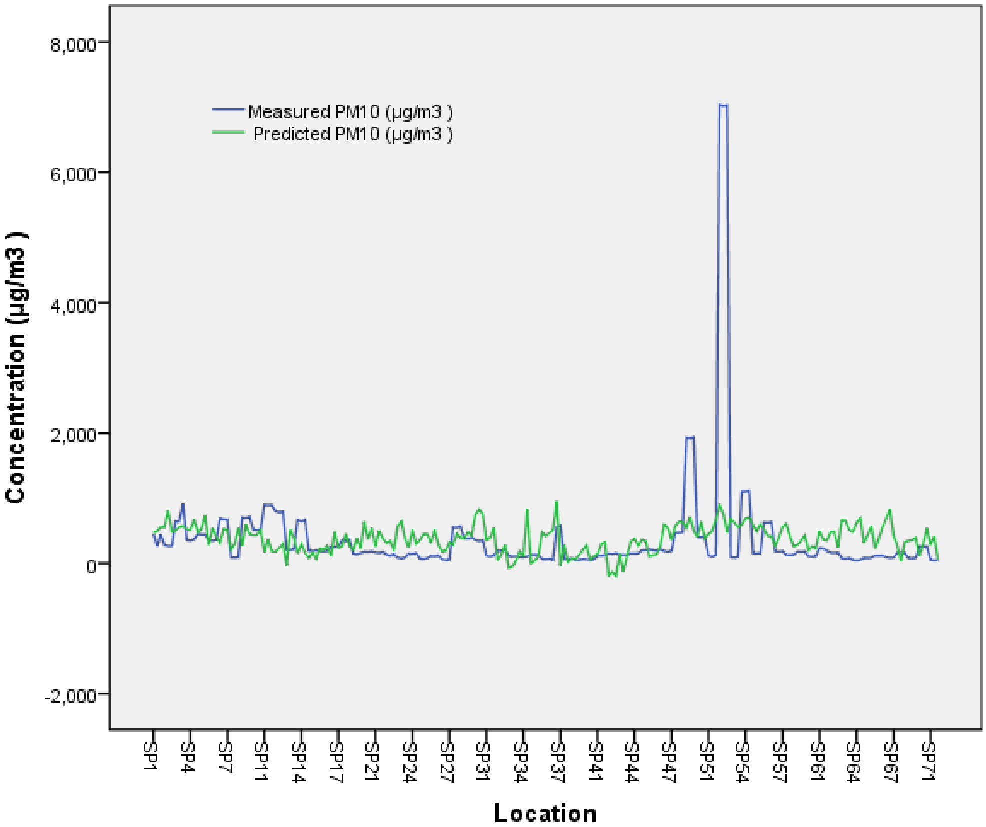
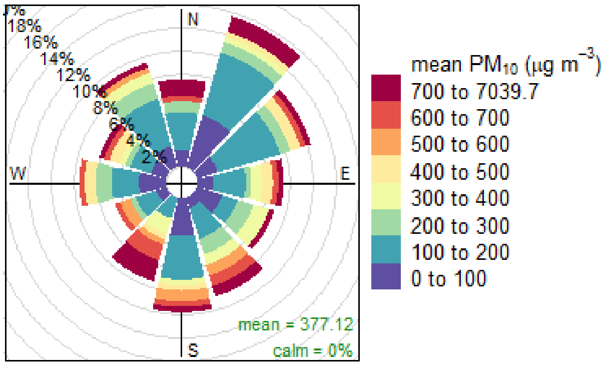
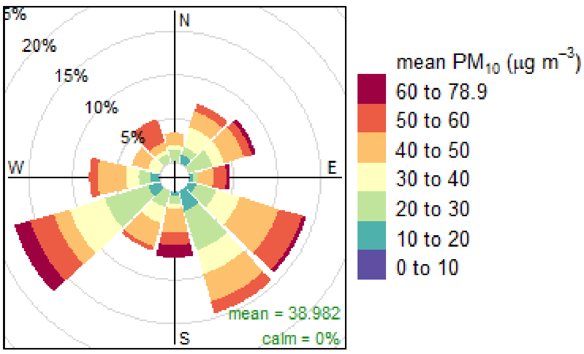


Figure 8: Predicted PM_{10} versus Measured PM_{10} in the Dry Season

The mean square error (MSE) and the root mean square error of the derived model were computed to be 1946295.489µg/m^{3}and 1395.097µg/m^3 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 be 9731477.447µg/m^3, 144085510.746µg/m^{3}and 153816988.193µg/m^3 respectively as shown in Table 2. The result (Table 2) showed that meteorological parameters significantly influence the concentration of PM_{10} in the area (P-value <0.05). However, the goodness of fit (Figure 7) indicates a poor linear relationship between PM_{10} and meteorological parameters with a coefficient of determination (R^2) of 0.063. This implies that only 6.3% of the variation of PM_{10} concentrations can be explained by the meteorological parameters. The goodness of fit between predicted and measured concentrations of PM_{10} is shown in Figure 7, while the predicted values are plotted against measured values as shown in Figure 8.



(a) Dry season



(b) Wet season

Figure 9: Pollution Roses of PM_{10} in the Study Area in the Dry and Wet Seasons

V. Conclusion

The study revealed that meteorological variables significantly affect the air pollutants in the study area. Poor linear relationship was also observed between meteorological variables and air pollutant.

References

[1]. Antai, R. E., Osuji, L. C. and Beka, F. T. (2016). Evaluation and Methodological Approach to Air Pollution Contamination and its Associated Risk in Uyo Metropolis, Akwa Ibom State, Nigeria. *International Journal for Innovative Research in Multidisciplinary Field*, 2 (10): 544-549.

[2]. Ahove, M.A.N. (2006). *The Nigerian Environment, National Open University of Nigeria,* Lagos. Reagent Printing and Publishing Co. P 213.

[3]. Bhatia, S.C. (2011). *Environmental Chemistry* Satish Kuma Jain New Delhi, India.

[4]. Efe, S. I., (2005). Urban Effects on Precipitation Amount, Distribution and Rain Water Quality in Warri Metropolis. Ph.D. Thesis, Dept of Geography and Regional Planning Delta State University Abraka, Delta State Nigeria. 2-47.

[5]. Efe, S.I., (2006). Particulate Pollution and its Health Implications in Warri Metropolis. Delta State Nigeria. *Env Anal*, 11: 1339-1351.

[6]. Gobo, A. E., Ideriah, T. J. K., Francis, T. E., and Stanley, H. O. (2012). Assessment of Air Quality and Noise AroundOkrika Communities, Rivers State. *Journal of Applied Science Environment, Management*, 16 (1): 75-83.

[7]. Kochubovski, M. and Kendrovski, V., (2012). Monitoring of the Ambient Air Quality (PM_{10}) in Skopje and Evaluation of the Health Effects in 2010. *Journal of Environmental Protection and Ecology,* 13 (2): 789-796.

[8]. Olowoporoku, D. (2011). *How clean is the air Nigerians breathe?* A case for national air quality management framework.

[9]. Okecha, S.A. (2000). *Pollution and Conservation of Nigerians Environment*. EkpomaT'Afrique Inter W.A.

[10]. WHO. (1976). Selected Methods of Measuring Air Pollutants. WHO offset publication No. 24E, World Health Organisation, Geneva.

Antai, Raphael E., *etal*. "Seasonal Investigation of Meteorological Variables Effects on Air Pollution in Eleme, Rivers State, Nigeria."*IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 14(4), (2020): pp 23-30.