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Forecasting and Modeling of Wet Seasons Air Quality ChangesUsing Multiple Linear Regression Model in Port Harcourt and Its Environs,Niger Delta, Nigeria.

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Abstract: *Port Harcourt and its environs is the hub of oil and gas activities in Niger Delta of Nigeria. It has been reported in several studies on associated adverse impact of particulate matters and noxious gases on man and environment as receptors as a result of the above noted sources of air pollution.The complaints by the residents of the study area over alarming air pollution of Port Harcourt and its environs in recent time necessitated the rationale for this research.Air quality impacts on the environment can therefore, be quantified by simulating environmental conditions. The effective and efficient way to understand the interactions of various air pollution scenarios as they relate with meteorology, topography and existing air quality characteristics are air pollution models. Linear regressions and multiple linear regressionsmodels were developed to forecast the influence of meteorological parameters on air pollutants in the wet season. The yearly forecasting model for the relationship between air pollutants and year was also developed for the annual forecasting of the future pollutant concentrations in the wet seasons for period of the next fifteen years using regression analysis and year as the predictor variable. On this note, this work was designed to develop a model for relationship between air pollutants and meteorological parameters and to forecast future pollution trend in the wet seasons in the study area.*

Keywords*: Forecasting, Multiple linear regression modelling, Air quality changes, Wet season.*

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I. Introduction

The growing global problem in recent time is air pollution which is a product of natural and anthropogenic activities (Efe, 2006, Akpan, 2014, Gobo *et al*., 2012 and Antai*et al*., 2016)and the adverse effects of this pollution affect man and his environment.

Air pollutants from the points or mobile sources can be influenced by the meteorological variables. The management and the prediction of the air pollutants trend in the environment is gaining more attention in present time (Sudeshana*et al*., 2013). This trend of the air pollution can be predicted by the use of modeling. Modeling is an analytical tool or mathematical equations to identify the sources, quantify the impacts and predict the future behaviour of air pollutants in the environment through simulation of environmental conditions (OkpalaandYorkor, 2013). This research revealed how relationships between measured air pollutant concentrations and meteorological parameters were modeled using multiple linear regressions and generalized additive model. On this note,this study was designed specifically to assess air quality status of Port Harcourt and its environs and to develop a model for relationship between air pollutants andmeteorological parameters in the wet seasonand to assess the past and present air quality status of Port Harcourt and its environs and forecast future pollution trendsby developing the forecasting model in the wet seasons.

Study Location

Port Harcourt metropolis is located between latitudes $4^0$35' and $5^0$30' north and between longitudes $6^0$54' and $7^0$08' east. It covers an estimated area of 1811.6 square kilometers and is the capital of Rivers State. Port Harcourt was established in 1914 by the British colonial administration under Lord Lugard to meet the pressing economic needs of Europe. The metropolis lies at the heart of the Niger Delta, which is one of the world's richest wetlands. The Niger Delta is bounded on the south by the Atlantic Ocean, to the north by Imo and Abia States to the east by Akwa Ibom State and to the west by Bayelsa and Delta States. Some of the well known residential areas in Port Harcourt and its environs include: Port Harcourt Town, Obio/Akpor, Eleme, Oyigbo, Ikwerre and Etche Local Government Areas (Overview of Rivers State - Niger Delta Budget Monitoring Group,2005).

The main city of Port Harcourt lies within the Port Harcourt Local Government Area. The city consists of the former European quarters, now called Old Government Reservation Area (GRA) and new layout areas. Port Harcourt, which is ranked as the fifth largest city in Nigeria, is made up of the city itself,Obio/Akpor Local Government Area and parts of Eleme, Etche, Oyigbo and Ikwerre Local Government Areas. It has the second largest sea port in Nigeria. The metropolis is the hub of industrial, oil and gas, commercial, administrative and other activities in Rivers State. The city is often referred to as the Treasure Base of the Nation.

II. Materials And Methods

Model Development

Multiple linear regression (MLR) models were applied to forecast the variations of pollutant concentrations with meteorological parameters. The following steps (Figure1) were applied in the model building process.

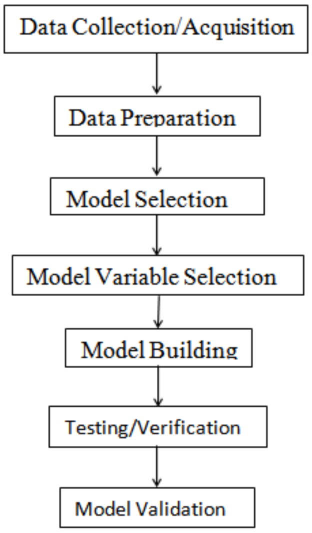


Figure 1: Model Building Process

i. Data was collected through field measurement,
ii. Data was prepared and analyzed using statistical software,
iii. Appropriate variables were selected as input parameters
iv. Models were built using the variables,
v. Models were tested and validated models, and
vi. Pollutants were predicted using built models

Multiple linear regression (MLR) modeling approach was employed to model the influence of meteorological variations on air pollutants.

Modeling was based on the following fundamental approaches:

$$\text{outcome}_i = (\text{model}) + \text{Error}_i \tag{1}$$

$$Y_i = (b_o + b_1 X_{i1} + b_2 X_{i2} + \ldots + b_n X_n) + \varepsilon_i \tag{2}$$

$$y_i = \beta_o + \sum_{i=1}^{n} \beta_i x_i + \varepsilon_i \tag{3}$$

Where; Y_i and y_i are model outcomes or outputs,
$X_1, X_2, \ldots\ldots, X_n$ are predictor variables,
$b_0, b_1, b_2, \ldots\ldots, b_n$ are regression coefficients, and
ε_i is the error factor called residual.

Multiple linear regressions (MLR) modeling technique was employed to predict air pollutants concentration in the study area using wind speed (Ws), wind direction (Wd), temperature (Temp), air pressure (Ap) and relative humidity (Rh) as predictor variables. The multiple linear regressions were performed using Statistical Package for the Social Science (SPSS) software, originally developed by International Business Machines (IBM). Stepwise regression approach was used to determine the relationship between air pollutants and individual meteorological parameter. Stepwise regression of independent parameter was performed using Equations (3) and (4).

$$PM_{pred} = f(X_i)$$

$$PM_{pred} = f(Wsp_i, \mathrm{Wd_i}, \mathrm{Temp_i}, \mathrm{Rh_i}) \quad (4)$$

Model Validation

The model performance was evaluated in consistent with guidelines instituted by EPA (2007). Specific analyses was performed to validate the model outputs against measured data. Both quantitative (statistical) and qualitative (visual) methods was adopted. Measured data was paired against predicted values. various statistical parameters such as mean square error (MSE), root mean sqaure error (RMSE) were used to validate and determine the quality of the prediction models. In addition, a measure of goodness of fit known as coefficient of determination, R-sqaure (R^2) was used to determine the total variability in the dependent variables that is accounted for by the model eqautions.

The mean square error (MSE) was computed as the mean difference between predicted and measured values using Equation (5), while the root mean square error was computed using Equation (6).

$$MSE = \frac{1}{N}\sum_{i=1}^{n}\left(Y_{pred,i} - X_{meas,i}\right) \quad (5)$$

$$RMSE = \left[\frac{1}{N}\sum_{i=1}^{n}\left(Y_{pred,i} - X_{meas,i}\right)^2\right]^{\frac{1}{2}} \quad (6)$$

where N is the number of measured data or observations.

Sum of square error (SSE) will be calculated using equation (7)

$$SSE = \sum\left(X_{meas,i} - \bar{X}\right)^2 \quad (7)$$

The sum of squares of the regression model (SS_M) was computed using Equation (8).

$$SS_M = \sum_i\left(Y_{pred,i} - X_{meas,i}\right)^2 \quad (8)$$

The residual sum of squares (RSS) was computed using Equation (9)

$$RSS = \sum_{i=1}^{n}\left(\varepsilon_i\right)^2 = \sum_{i=1}^{n}(y_i - f(x_i))^2 \quad (9)$$

The residual sum of square error is therefore computed as

The residual sum of squares (SS_R) was computed using Equation (10).

$$SS_R = \sum_i\left(Y_{pred,i} - \bar{X}\right)^2 \quad (10)$$

The total sum of squares (SS_T) was computed using Equation (11).

$$SS_T = \mathrm{SS_M} + SS_R = \sum_i\left(X_{meas,i} - \bar{X}\right)^2 \quad (11)$$

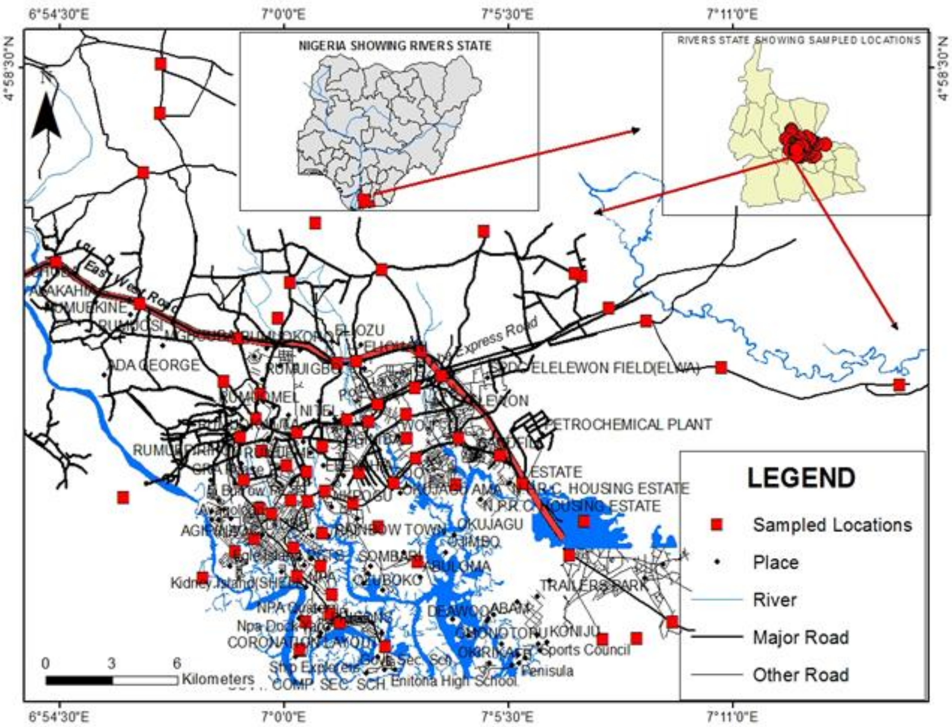


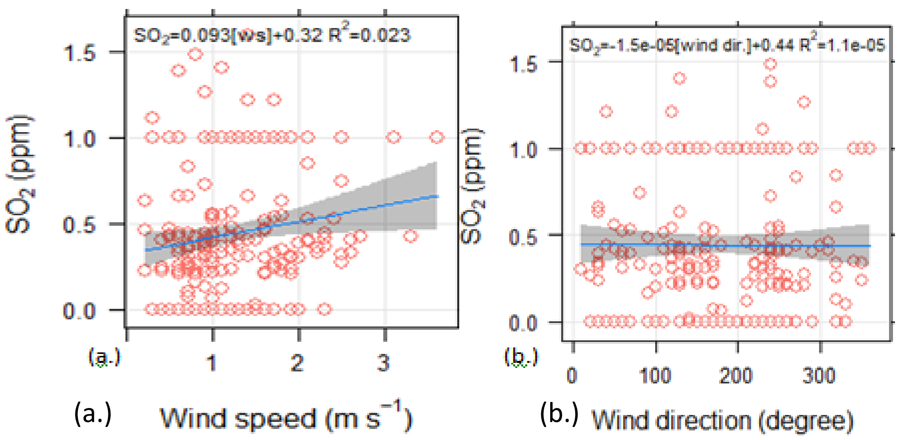
Figure 2: Port Harcourt and its Environs showing Sampling Points for the Study

III. Presentation Of Results

(i) Variation of Sulphur Dioxide (SO_2) with Meteorological Parameters in the Wet Season

The linear models (shown in Table1) was derived from the stepwise regression of SO_2 with each meteorological parameter indicating that the linear variations between concentrations of SO_2 and wind speed and relative humidity are highly significant at 0.05 confidence level ($P < 0.05$). Conversely, the linear variations between wind direction, temperature and air pressure are not highly significant at 0.05 confidence levels ($p > 0.05$). The results (Figure 3 (a-e)) further indicated that SO_2 concentrations correlated positively with wind speed, and temperature with coefficient of determinations (R^2) of 0.023 and 0.0055 respectively, and varied negatively with wind direction, relative humidity, and air pressure with coefficient of determinations of $1.1\text{x}10^{-5}$, 0.019 and 0.0064 respectively.

These results revealed that wind speed accounted for 2.3%, wind direction accounted for 0.0011%, relative humidity accounted for 1.9%, and temperature accounted for 0.55%, while air pressure accounted for 0.64% of the total variation of SO_2 concentrations in the wet season.



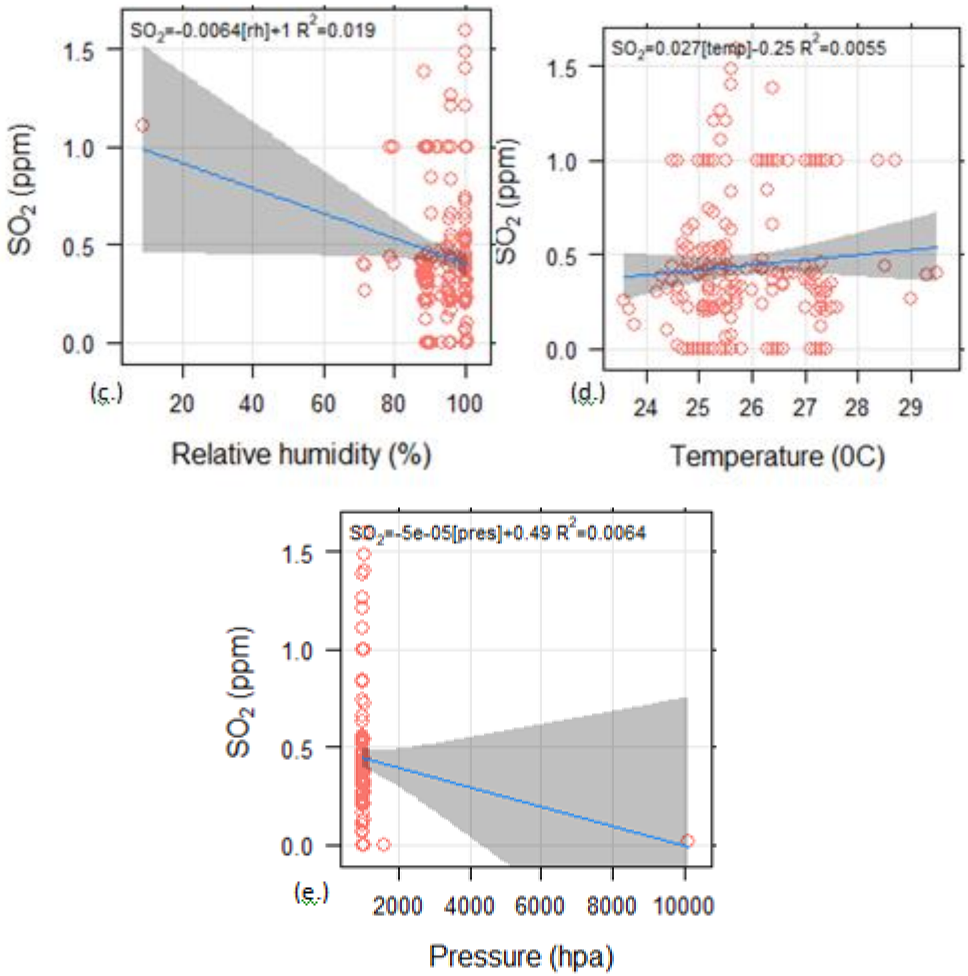


Figure 3 (a-e): Relationship between Predicted SO_2 and Meteorological Parameters in the Wet Season

Table 1:Stepwise Linear Models for SO_2 in the Wet Season

Pollutant	Model	R^2	t-statistic	Sig. (2-tailed)
SO_2	$= 0.32 + 0.093*Wsp$	0.023	2.868	0.005^{**}
	$= 0.44 – 1.5x10^{-5}*Wd$	$1.1x10^{-5}$	-0.582	0.561
	$= 1.0 – 0.0064*Rh$	0.019	-2.201	0.029^{*}
	$= -0.25 + 0.027*Temp$	0.0055	-0.092	0.927
	$= 0.49 – 5.0x10^{-5}*Pres$	0.0064	-1.124	0.262

***** Correlation is highly significant at the 0.05 level (2-tailed).
**Correlation is highly significant at the 0.01 level (2-tailed).

A multiple linear regression model was developed by combining all the meteorological parameters predictor variables and a model for the prediction of SO_2 concentrations in the wet season was derived as shown in Equation (12). The derived Equation (12) was used to predict the concentrations of SO_2 in the study area in the wet season.

$$\mathbf{SO_2 = 1.271 + 0.123*Wsp + 0.0*Wd - 0.009*Rh - 0.003*Temp - 4.715x10^{-5}*Pres} \quad (12)$$

Table 2: Analysis of Variance (ANOVA) for Wet Season SO_2 Prediction Model

Model	SSE (ppm)	df	MSE (ppm)	RMSE (ppm)	F	Sig.
Regression Error (SS_M)	2.019	5	0.404	0.636	2.795	$.018^{*}$
Residual Error (SS_R)	29.911	207	0.144	0.380		
Total Error (SS_T)	31.930	212				

* Highly significant at the 0.05 confidence level (2-tailed).

The mean square error (MSE) and the root mean square error of the model were computed to be0.404ppm and 0.636ppm 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 be2.019ppm,29.911ppmand31.930ppm respectively as shown in Table 2. The result (Table 2) showed that meteorological parameters significantly influence the concentrations of SO_2 in the area (P-value <0.05). The goodness of fit (Figure 4) between predicted and measured values indicated a poor linear relationship between concentrations of SO_2 and meteorological parameters with a coefficient of determination (R^2) of 0.063.

This implies that meteorological parameters accounted for only 6.3% of the total variation of SO_2 concentrations in the wet season and are explained by the meteorological parameters. The goodness of fit between predicted and measured concentrations of SO_2 is shown in Figure 4, while the predicted values are plotted against measured values as shown in Figure 5.

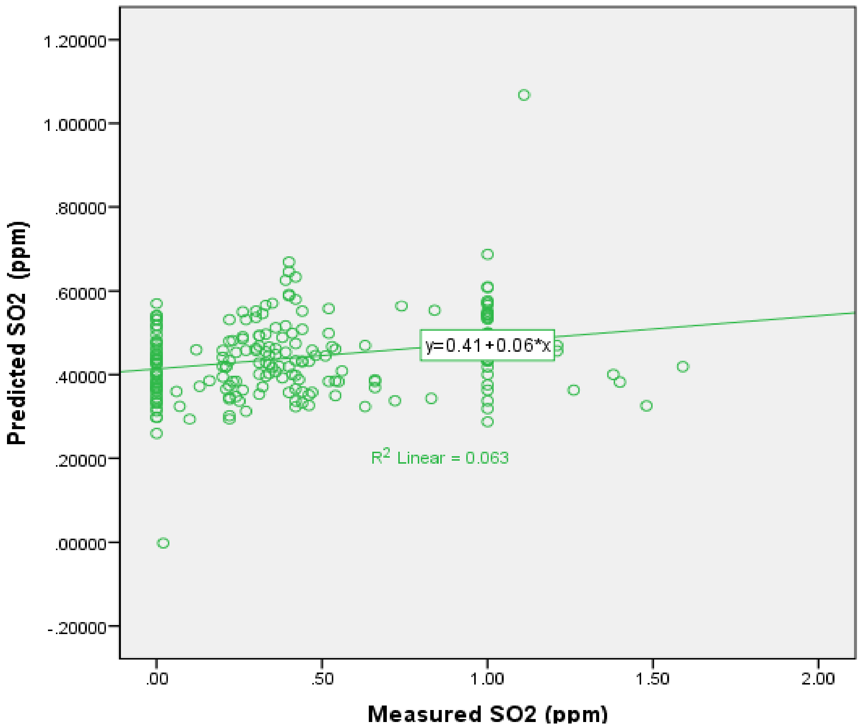


Figure 4: Best fit of Predicted SO_2 and Measured SO_2 in the Wet season

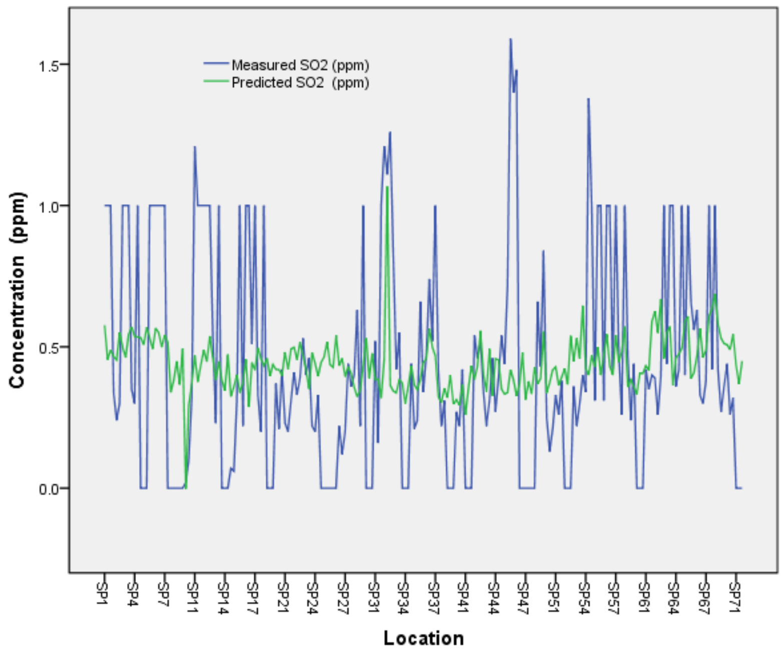


Figure 5: Predicted SO_2 versus Measured SO_2 in the Wet Season

(ii) Variation of Nitrogen Dioxide (NO_2) with Meteorological Parameters in the Wet Season

The linear models (shown in Table 3) was derived from the stepwise regression of NO_2 with each meteorological parameter indicating that the linear variations between concentrations of NO_2 and wind speed are highly significant at 0.05 confidence level ($P < 0.05$). Conversely, the linear variations between wind direction, relative humidity, temperature and air pressure are not highly significant at 0.05 confidence levels ($p > 0.05$). The results (Figure 6 (a-e)) further indicated that NO_2 concentrations correlated positively with wind speed, and temperature with coefficient of determinations (R^2) of 0.014 and 0.022 respectively, and varied negatively with wind direction, relative humidity, and air pressure with coefficient of determinations of 0.0012, 0.017 and 0.0021 respectively. These results revealed that wind speed accounted for 1.4%, wind direction accounted for 0.12%, relative humidity accounted for 1.7% and temperature accounted for 2.2%, while air pressure accounted for 0.21% of the total variation of NO_2 concentrations in the wet season.

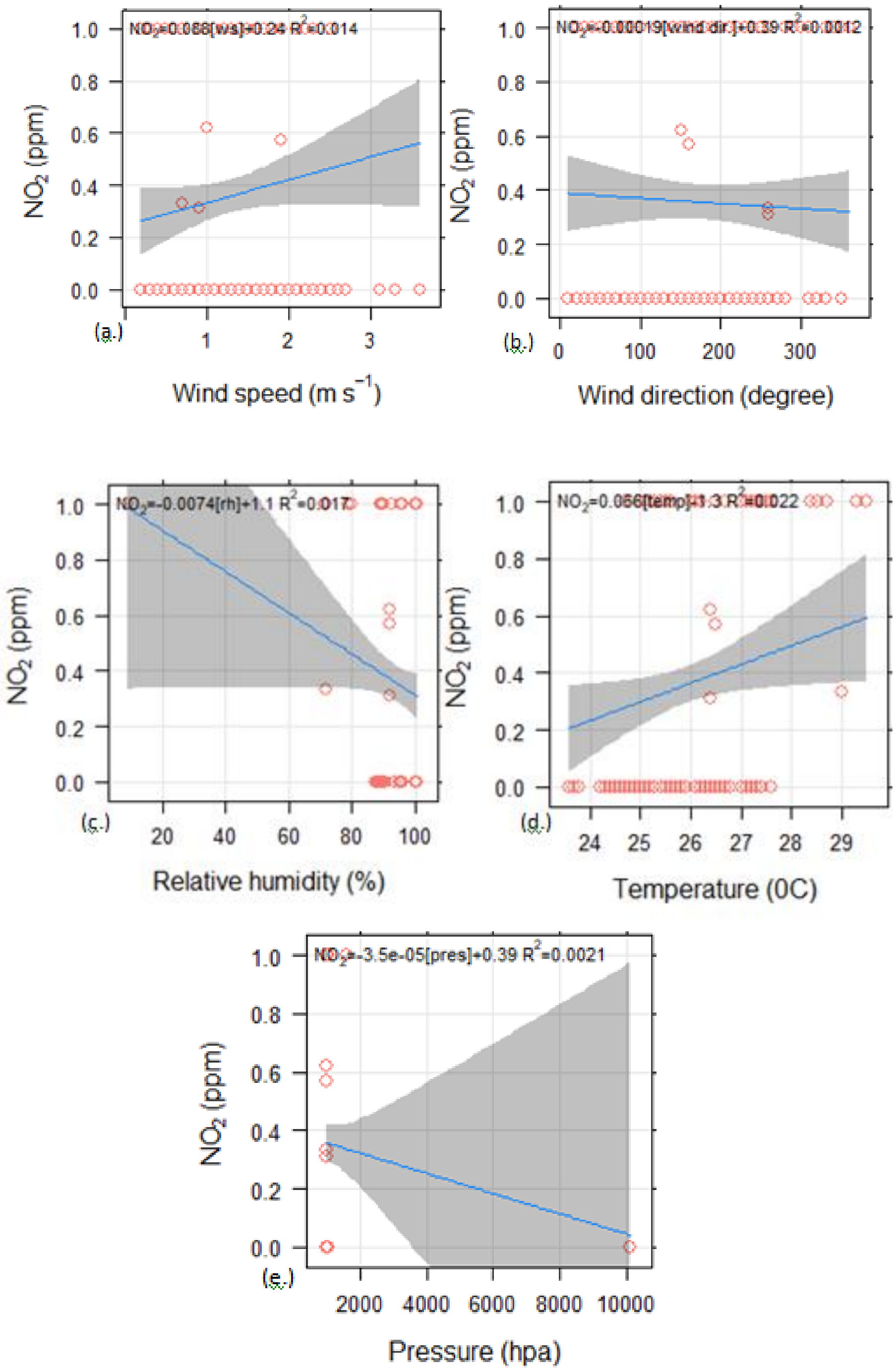


Figure 6 (a-e): Relationship between Predicted NO_2 and Meteorological Parameters in the Wet Season

Table 3:Stepwise Linear Models for Wet Season NO_2

Pollutant	Model	R^2	t-statistic	Sig. (2-tailed)
NO_2	= 0.24 + 0.088*Wsp	0.014	2.416	0.017*
	= 0.39 – 0.00019*Wd	0.0012	-0.919	0.359
	= 1.1 – 0.0074*Rh	0.0017	-1.150	0.251
	= -1.3 + 0.066*Temp	0.022	1.385	0.167
	= 0.35 – $3.5x10^{-5}$*Pres	0.0021	-0.521	0.603

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

A multiple linear regression model was developed by combining all the meteorological parameters predictor variables and a model for the prediction of concentrations of NO_2 in the wet season was derived as shown in Equation (13). The derived Equation (13) was used to predict the concentrations of NO_2 in the study area in the wet season.

$$\mathbf{NO_2 = -552 + 0.128*Wsp - 0.0*Wd - 0.006*Rh + 0.053*Temp - 2.691x10\text{-}5*Pres} \quad (13)$$

Table 4: Analysis of Variance (ANOVA) for Wet Season NO_2 Prediction Model

Model	SSE (ppm)	df	MSE (ppm)	RMSE (ppm)	F	Sig.
Regression Error (SS_M)	2.670	5	0.534	0.731	2.443	0.035*
Residual Error (SS_R)	45.248	207	0.219	0.468		
Total Error (SS_T)	47.918	212				

*Highly significant at the 0.05 confidence level (2-tailed).

The mean square error (MSE) and the root mean square error of the model were computed to be0.534ppm and 0.731ppm 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 be2.670ppm,45.248ppmand47.918ppm respectively as shown in Table 4. The result (Table 4) showed that meteorological parameters significantly influence the concentrations of NO_2 in the area (P-value <0.05). The goodness of fit (Figure 7) between predicted and measured values indicated a poor linear relationship between concentrations of NO_2 and meteorological parameters with a coefficient of determination (R^2) of 0.056. This implies that meteorological parameters accounted for only 5.6% of the total variation of NO_2 concentrations in the wet season and are explained by the meteorological parameters. The goodness of fit between predicted and measured concentrations of NO_2 is shown in Figure 7 while the predicted values are plotted against measured values as shown in Figure 8.

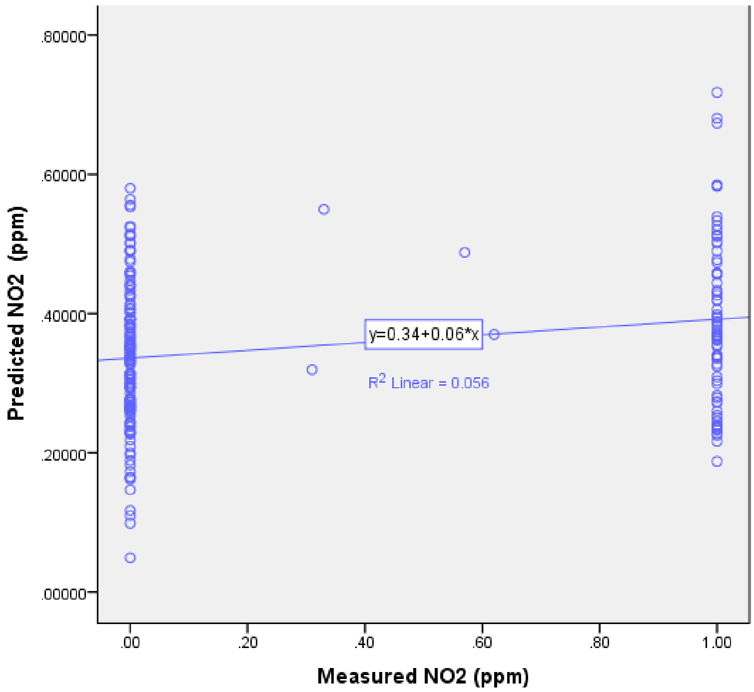


Figure 7: Best fit of Predicted NO_2 and Measured NO_2 in the Wet Season

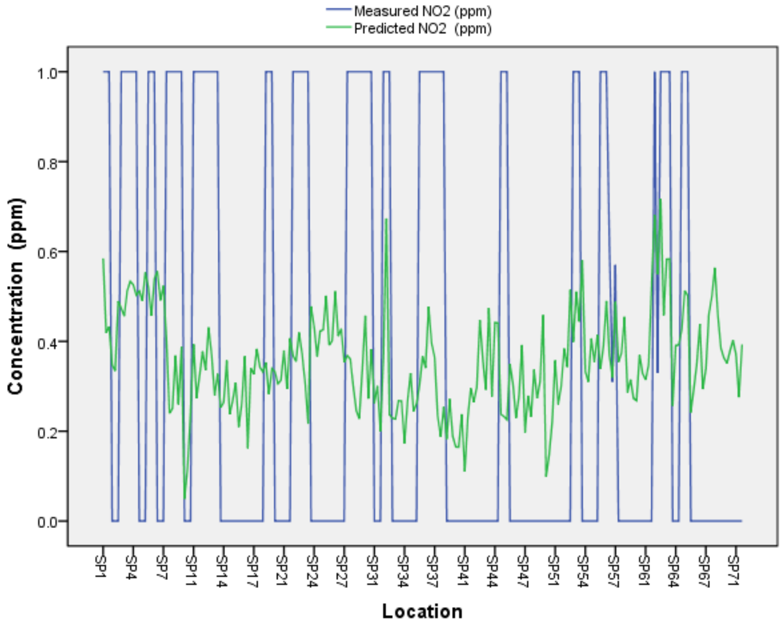
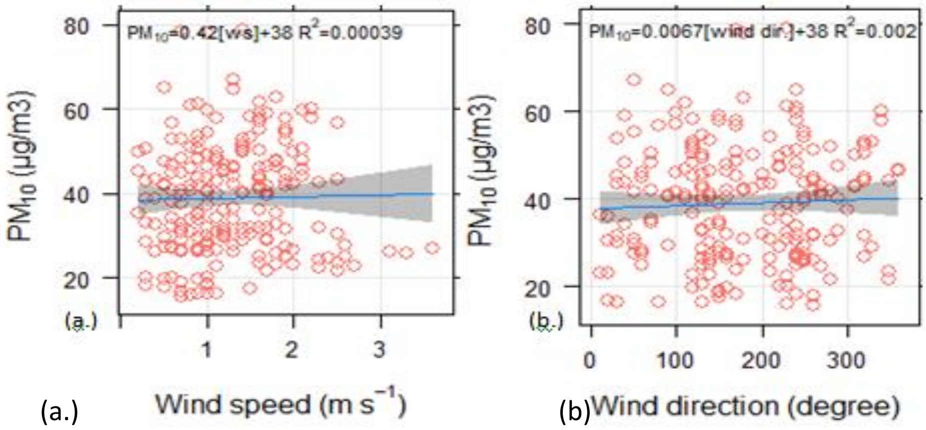


Figure 8: Predicted NO_2 versus Measured NO_2 in the Wet Season

Variation of PM_{10}Particulate Matter (PM_{10})with Meteorological Parameters in the Wet Season

The linear models (shown in Table 5) was derived from the stepwise regression of PM_{10} with each meteorological parameter indicating that the linear correlation between concentrations of PM_{10} and all meteorological parameters are not highly significant at 0.05 confidence level ($P > 0.05$). The results (Figure 9 (a-e)) indicated that PM_{10} concentrations correlated positively with wind speed, wind direction, relative humidity and air pressure with coefficient of determinations (R^2) of 0.0039, 0.002, 0.012 and 0.0052 respectively, and varied negatively with temperature with coefficient of determinations of 0.0088. These results revealed that wind speed accounted for 0.39%, wind direction accounted for 0.2%, relative humidity accounted for 1.2%, and temperature accounted for 0.88%, while air pressure accounted for 0.52% of the total variation of PM_{10} concentrations in the wet season.



(a.) (b)

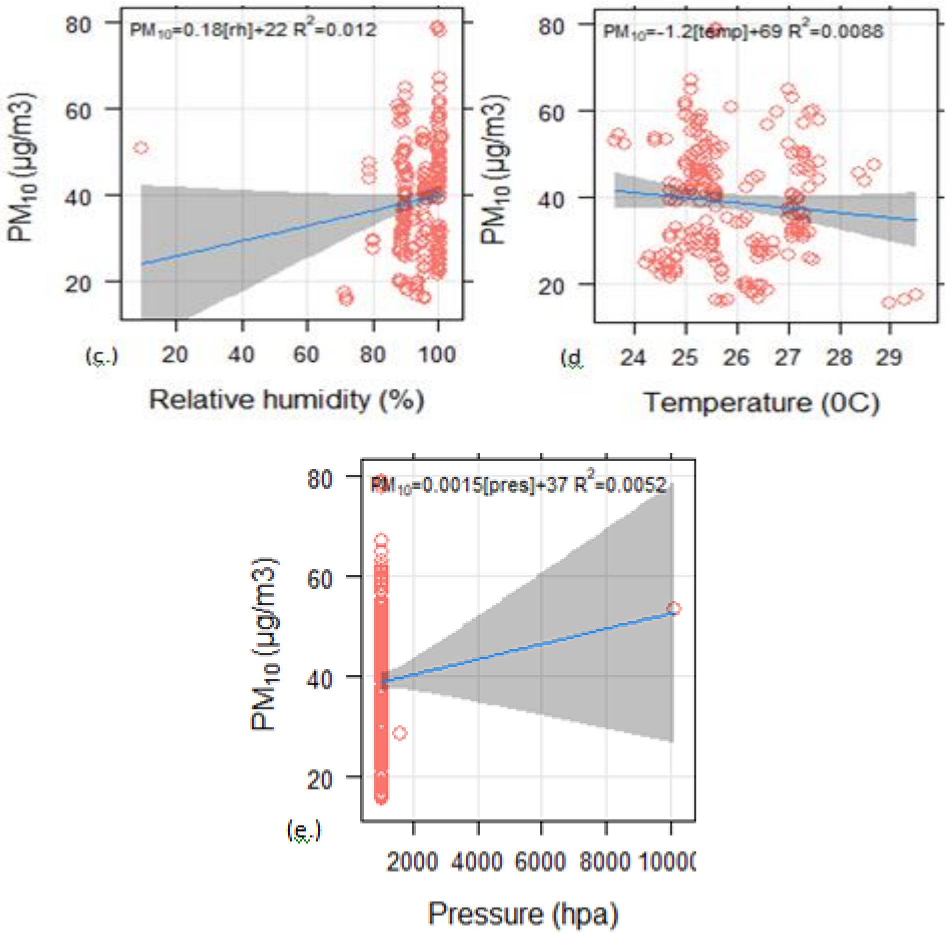


Figure 9 (a-e): Relationship between Predicted $PM_{10}$and Meteorological Parameters in the Wet Season

Table 5:Stepwise Linear Models for PM_{10} in the Wet Season

Pollutant	Model	R^2	t-statistic	Sig. (2-tailed)
PM_{10}	= 38.0 + 0.42*Wsp	0.00039	-0.174	0.862[a]
	= 38.0 + 0.0067*Wd	0.002	0.676	0.500[a]
	=22.0 + 0.18*Rh	0.012	1.030	0.304[a]
	= 69.0 – 1.2*Temp	0.0088	-0.390	0.694[a]
	= 37.0 + 0.0015*Pres	0.0052	0.949	0.344[a]

a = Not highly significant at the 0.05 confidence level (2-tailed).

A multiple linear regression model was developed by using all the meteorological parameters independent predictor variables and a model for the prediction of PM_{10} concentrations in the wet season was derived as shown in Equation (14). The derived Equation (14) was used to predict the concentrations of PM_{10}in the study area in the wet season.

$$\mathbf{PM_{10} = 33.959 - 0.259*Wsp + 0.007*Wd + 0.144*Rh - 0.422 + 0.001*Pres} \qquad (14)$$

Table 6: Analysis of Variance (ANOVA) for Wet Season PM_{10} Prediction Model

Model	SSE	df	MSE	RMSE	F	Sig.
Regression Error (SS_M)	732.511	5	146.502	12.104	0.835	0.526[a]
Residual Error (SS_R)	36330.561	207	175.510	13.248		
Total Error (SS_T)	37063.072	212				

a = Not highly significant at the 0.05 level (2-tailed).

The mean square error (MSE) and the root mean square error of the model were computed to be146.502µg/m^{3}and 12.104µg/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 732.511µg/m^3,36330.561µg/m^{3}and37063.072µg/m^3 respectively as shown in Table 6. The result (Table 6) showed that meteorological parameters did not significantly influence the concentrations of PM_{10} in the area (P-value >0.05). The goodness of fit (Figure 10) between predicted and measured values indicated a poor linear relationship between concentrations of PM_{10} and meteorological parameters with a coefficient of determination (R^2) of 0.020. This implies that meteorological parameters accounted for only 2.0% of the variation of PM_{10} concentrations in the wet season and are explained by the meteorological parameters. The goodness of fit between predicted and measured concentrations of PM_{10} is shown in Figure 10 while the predicted values are plotted against measured values as shown in Figure 11.

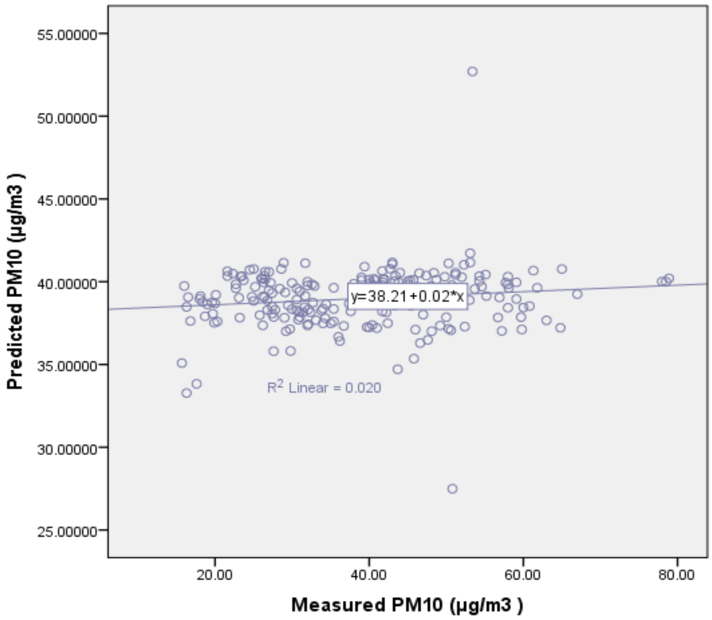


Figure 10: Best fit of Predicted PM_{10} and Measured PM_{10} in the Wet Season

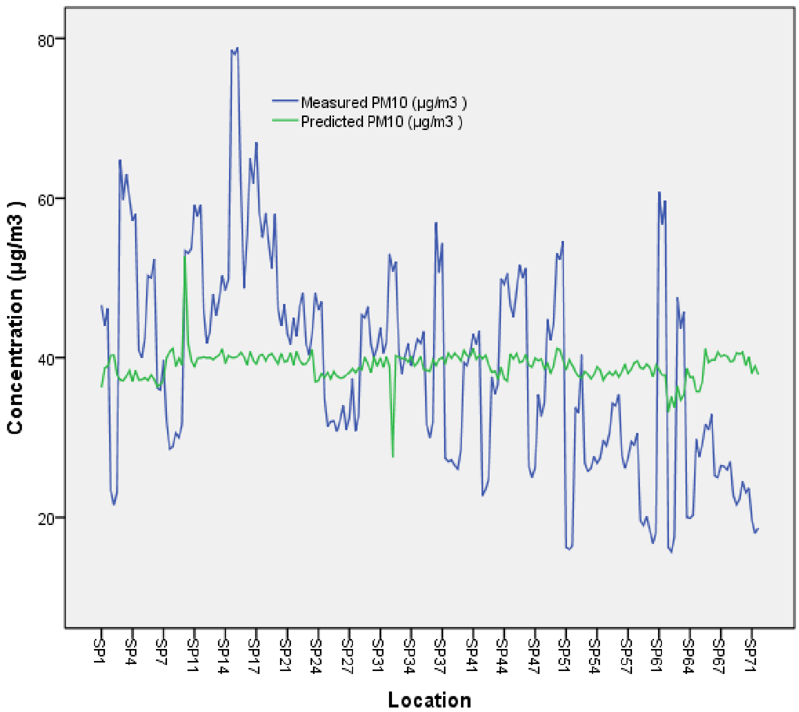


Figure 11: Predicted PM_{10} versus Measured PM_{10} in the Wet Season

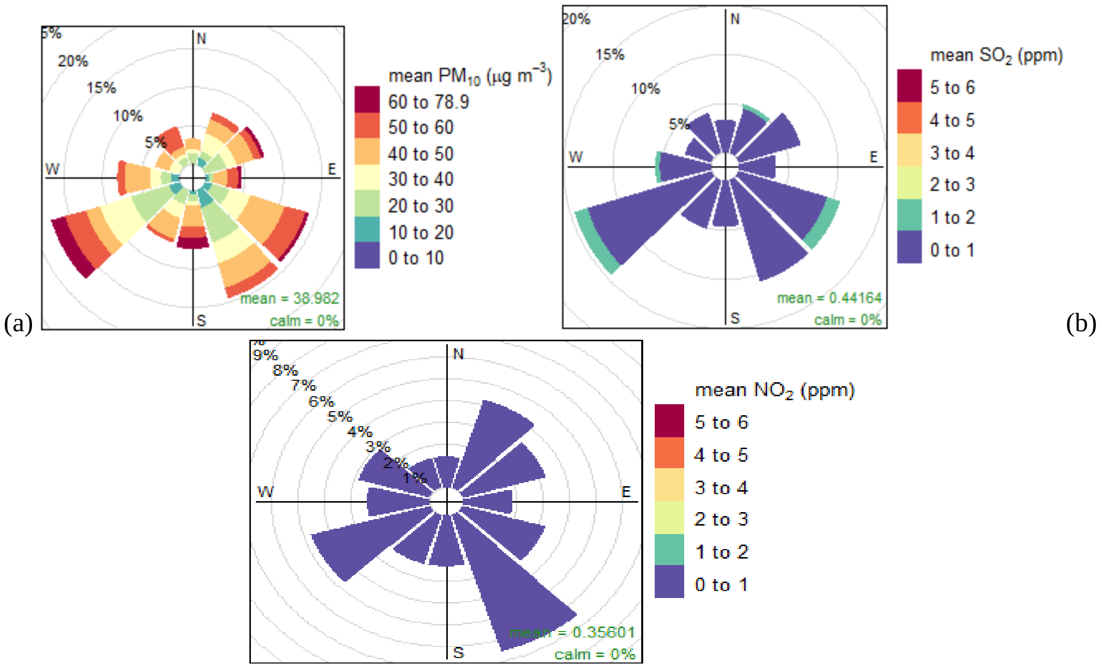
IV. Interpretation And Discussion

Modeling the relationship between air pollutants and meteorological parameters in the wet season

(A) Assessment of Pollutants Dispersion Trend in the Study Location in the Wet Season

Trends in dispersion of pollutants in the study location in the wet were also assessed using pollution roses and bivariate polar plots of each pollutant with regards to wind speed and wind direction. The wet season results are presented in Figures 12 (a-c) and 13 (a-c). The pollution roses and polar plots were again developed using the mean concentration of each pollutant in different wind speed and percentage frequency count of wind direction categories (Munir, 2016). They were simulated with the aid of Generalized Additive Model (GAM) smoothing techniques Carslaw, (2015) that depict pollutant concentrations as a continuous surface.

Wet season pollution roses (Figure 12 (a-c)) revealed that pollutant concentrations increase with increased wind speed. Low concentrations of pollutants were obtained at low wind speed and vice-versa. This implies that wind speed has positive impact on the concentration levels of pollutants in the study location. Wind directions in the wet season were more prevalent in south-west and south-east as illustrated in the pollution roses of Figure 12 (a-c).



(c)

Figure 12(a-c): Pollution Roses of Pollutants in the Study Area in the Wet Season

The wet season pollutant polar plots (Figure 13(a-c)) revealed that concentrations of air pollutants in the locations are characterizedwith wind speed up to 2.5m/s. It is also shown from Figure 13 (a-c) that pollutants concentrations increase with increased wind speed.

Surface polar plots of pollutants concentrations in the study locationshowed that high concentrations of SO_2 ischaracterized with thesouth-east, south-west and north-east directions and are dispersed toward the north-west direction. This may mean that sources of this pollutant are in the south-eastern, south western and north-eastern part of the study location. NO_2 is characterized with both south-east and south-west directions and is dispersed towards north-east and north-west directions. This may mean that sources of this pollutantare in the south-eastern and south-western part of the study location. The Figure also revealed that concentrations of Particulate matter (PM_{10}) in the wet season ischaracterized with all the wind directions; Particulate matter(PM_{10}) ispredominant in the eastern direction. The pollutants dispersion patterns in the wet season revealed that pollutants are from diffuse sources probably caused by industrial activities, unprofessional destruction of artisanal refineries and bunkering facilities/petroleum products in the coastal area, vehicular exhaust emissions and asphalt plantsin both the coastal and up-land areas and influenced by the dynamic nature of wind trend in the wet season.

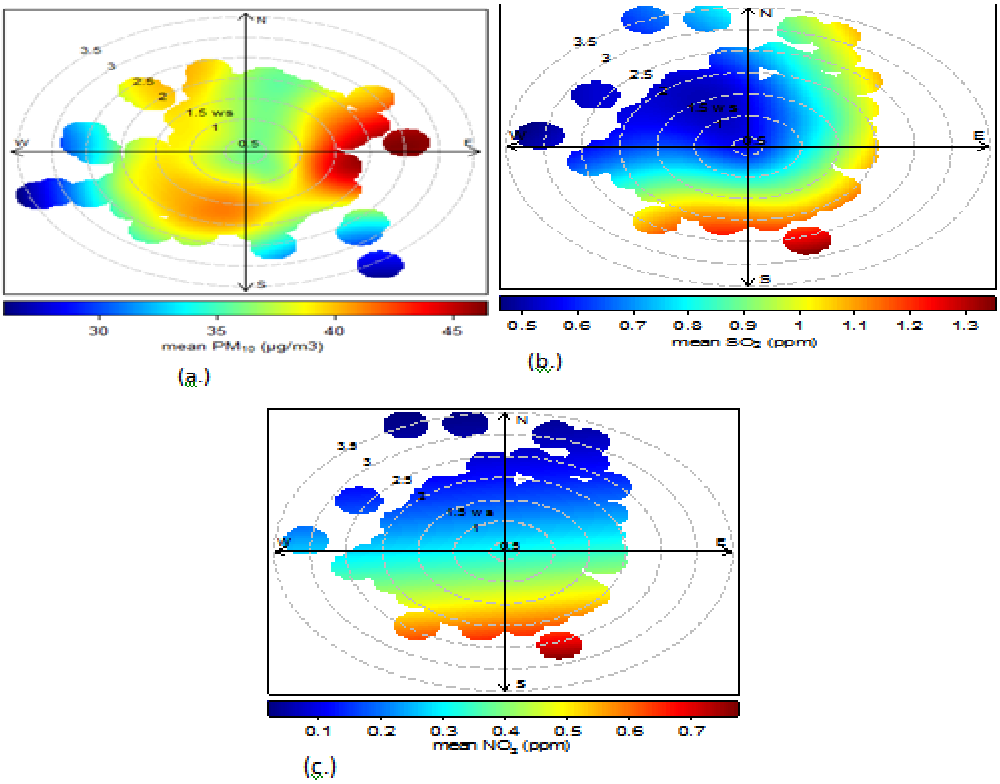


Figure 13(a-c): Polar Plots of Pollutants in the Study Area in the Wet Season.

Yearly Prediction for 15 years for Wet Seasons

Yearly prediction of air pollutants was carried out using a ten year data from previous studies conducted in the study area.

The prediction was done using regression analysis and year as the predictor variable. The relationship between air pollutants and year was therefore established. The annual prediction of pollutant concentrations was made for wet seasons. The prediction models for each pollutant in the wet seasonare presented in Equations (15 to 24). The prediction was made for a period of fifteen years (2017 to 2031) and the results of the annual prediction are presented in Table 7 for the wet seasons.

Wet Season Yearly Prediction for Wet Season

$$TSP = 6865.138 - 3.38644*Year \quad (15)$$

$$PM_{10} = 3264.973 - 1.60861*Year \quad (16)$$

$$PM_{2.5} = -919.817 + 0.458424*Year \quad (17)$$

$$SO_2 = -91.10053 + 0.04526*Year \quad (18)$$

$$NO_2 = -61.949 + 0.03097*Year \quad (19)$$

$$H_2S = 17.9504 - 0.00867*Year \quad (20)$$

$$VOCs = -95.067 + 0.0472*Year \quad (21)$$

$$CO = -540.713 + 0.270424*Year \quad (22)$$

$$NH_3 = -296.2905 + 0.14721*Year \quad (23)$$

$$CH_4 = -302.657 + 0.150909*Year \quad (24)$$

Table 7: Predicted Yearly Wet Seasons Values for 15 Years

Year	TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_2	H_2S	VOCs	CO	NH_3	CH_4
	µg/m^3			ppm						
2017	34.69	20.41	4.82	0.19	0.52	0.46	0.14	4.73	0.63	1.73
2018	31.30	18.80	5.28	0.23	0.55	0.45	0.18	5.00	0.78	1.88
2019	27.92	17.19	5.74	0.28	0.58	0.45	0.23	5.27	0.93	2.03
2020	24.53	15.58	6.20	0.32	0.61	0.44	0.28	5.54	1.07	2.18
2021	21.14	13.97	6.66	0.37	0.64	0.43	0.32	5.81	1.22	2.33
2022	17.76	12.36	7.12	0.42	0.67	0.42	0.37	6.08	1.37	2.48
2023	14.37	10.75	7.57	0.46	0.70	0.41	0.42	6.35	1.52	2.63
2024	10.98	9.15	8.03	0.51	0.73	0.40	0.47	6.63	1.66	2.78
2025	7.60	7.54	8.49	0.55	0.77	0.39	0.51	6.90	1.81	2.93
2026	4.21	5.93	8.95	0.60	0.80	0.38	0.56	7.17	1.96	3.08
2027	0.82	4.32	9.41	0.64	0.83	0.38	0.61	7.44	2.10	3.24
2028	-2.56	2.71	9.87	0.69	0.86	0.37	0.65	7.71	2.25	3.39
2029	-5.95	1.10	10.33	0.73	0.89	0.36	0.70	7.98	2.40	3.54
2030	-9.34	-0.51	10.78	0.78	0.92	0.35	0.75	8.25	2.55	3.69
2031	-12.72	-2.11	11.24	0.82	0.95	0.34	0.80	8.52	2.69	3.84

V. Conclusion

The research revealed that changes in the air quality of Port Harcourt city and its environs are directly induced and influenced by changes in the meteorological variables in the wet season.

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]. Akpan, P.E, Usip, E.E and Jeremiah, U.O (2014). Impacts of Traffics Volumes on Air Quality in Uyo Urban, Akwa Ibom State, Nigeria. Journal of environment and earth science, 21: 189 – 2000.

[3]. Carslaw, D.C. (2015). The Open Air Manual - Open-Source Tools for Analyzing Air PollutionData. Manual for Version 1.1-4, King's College London.

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

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

[6]. Munir, S. (2016); Modelling the Non-Linear Association of Particulate Matter (PM10) With Meteorological Parameters and Other Air Pollutants-A Casestudy In Makkah. Arabian Journal of Geosciences. https://www.Researchgate.Net/Publication/287387686.

[7]. Okpala, A. N. and Yorkor, B., (2013). A Review of Modeling as a Tool for Environmental Impact Assessment. International Research Journal in Engineering Science and Technology, 10 (1):

[8]. Overview of Rivers State - Niger Delta Budget Monitoring Group. (2005). www.nigerdeltabudget.org/new/index.php/overview-of-rivers-state

[9]. Sudeshana, P., Alka, S., Ashok, K.S., and Srivastava, J.K. (2013). Modeling of Ambient For SO_XandNO_XPollutants Through Artificial Neural Network in Sensitive Area of Ujjain City.J. International Journal of Chemical Sciences and Applications. Department of Chemical Engineering, Ujjain Engineering College, Ujjain, (M.P), India.

[10]. USEPA. (2007). Diesel Emission Standards Implications for Fleet Operators. U.S. Environmental Protecting Agency.

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