Analysis of Variability of Atmospheric Pollutants in Ambient Air of Metropolitan City Karachi, and Environmental Sustainability

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Abstract: It is well known that, air pollution is a composite phenomenon and intense air pollution events are governed by huge number of consistent factors. In this study, we considered the pollutant parameter (NO_2, NO, NOx and CO) concentrations and were measured simultaneously during the period 21/11/2009 to 27/02/2010 in city of Karachi. The estimations were carried out to study the variability of pollutant emissions. Time Series analysis confirms the existence of variation in pollutant with mean daily concentration and the results suggest that the concentrations of pollutant over the interval are slowly declined. The relationships NO_2 with NOx, NO with NOx and NO_2 vs. CO were modeled with linear regression. The results of the linear regression detected underlying strong relationships among pollutant variables. The application of the regression approach confirmed that the NO_2 strongly correlated with other paired pollutants. The study will be helpful to the policy makers to control air pollution and the sustainable environment. It also needs to extend this research to study the nonlinear behavior of atmospheric pollutants in perspective of fractal dimension.

Keywords: Sustainable Environment, Air Pollution, time series analysis, environmental pollutant, traffic emissions.

1. INTRODUCTION

Monitoring of the pollutants is the most relevant issue in health protection, for the sustainable environmental and health concerned [1]. The effect of health mainly by the traffic exposure, industrial and other pollutants. The pollution may be due to Nitrogen oxides and Sulfur oxides as well as excess of carbons in urban areas and its vicinity. Concentrations of the ozone, non methane hydrocarbons and nitrogen oxides measured in the variety of rural, urban, suburban, and the remote locations. The apportionment of observed hydrocarbon species to stationary and the mobile sources of anthropogenic and biogenic propose that the emission inventories in the present-day in United States miscalculate the real size of mobile emissions [2]. The highly oxidizing environmental level, with that of the NO_2/NO ratio which relatively higher than many of the other regions. The ground level O_3x concern showed both on the weekend/weekday and the durational variations, generally increased from the beginning to the end of the study period [3]. Analyses the concentrations of the NO, NO_X, NO_2, and O_3 deliberated in Tianjin over the 38 complete days in the autumn. The results indicate cycle of ozone concentration in the mid-day at the peak and the lower at the night time concentrations. The up and down of the concentration of ozone in day and night due to the photochemical O_3 formation [4]. The air pollutant concentrations are studied using a site in Delhi during 2000–2009. Statistical persistence the concentration events of the CO and the NO_2 measured. Whereas the O_3 exceeding time series demonstrated anti-persistent behavior. This is mainly attributed to the secondary nature of O_3 concentrations. Further investigation by spectral analysis confirmed the anti-persistence in the O_3 level exceeding [5]. Potential force of the climate variability and the change on the air pollution relevant bad health effects in the United States. Health effects of the exposures to the sulfur dioxide, carbon monoxide, and the nitrogen dioxide that aggravation of existing cardiovascular diseases, reduced work capacity, and the effects on the pulmonary function, respiratory problems and the alterations the defense systems of lung [6].

The clear diurnal pattern in AH concentrations demonstrated the highest values in the morning and the very lowest values afternoon. It was suggested all of industrial sources and vehicular sources mainly associated to the Apodaca. it was observed that population in the MAM is not exposed to the severe air pollution episodes while the criteria pollutants lower values showed than maximum permissible values

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suggested by the Mexican air quality standards. The Benzene/VOCs ratios were showed that in multiple sampling periods that there contribution of the mixed sources to the levels of, industrial sources, vehicular emissions and punctual sources which more important than the industrial activities one [7]. The reported data from 2006–2007, in which the study of the black carbon concentrations ([BC]), calculated at the 5-min usual intervals with the Aethalometer in the Karachi, Pakistan. Study results revealed that daily mean [BC] results varied from the 1 to 15 μg m−3. But the short-term spikes were exceeding to the 40 μg m−3 were in most common, that occurring primarily during the morning and the evening in the rush-hour periods [8]. On the other hand the analysis of NOx analysis behavioral variations in the road atmosphere to further validate the roadside air quality simulation model (RSAQSM) (Minoura and Ito, 2009). The major public health concern and the burning issue, in which the excess of mortality and the morbidity were most common due to the hot weather and poor air quality in many metropolitan cities throughout world [1].

The aim of this research is to analysis the variability of the atmospheric Pollutants (NO, NO_2, NOx and CO) in the ambient air of the metropolitan city Karachi, Pakistan and its effect in daily life and the environment.

The analysis of this research study will be helpful to forecast and understand the chronological behavior of the concentrations of four pollutants which can be further utilized for the making policy decisions to control air pollution and for the sustainable environment in urban areas. To overcome the challenges about environmental pollutants in Pakistan especially in Karachi are to fill the gaps in information of atmospheric pollutants related to spatial and temporal variations of exposure to health, it is necessary to study further the complex nature of atmospheric pollutants in perspective of fractal dimension.

2. DATA AND METHODS OF ANALYSIS

The daily mean values of pollutant NO_2, NO, NOx and CO from 21/11/2009 to 27/02/2010 (98 days) were obtained from Environmental protection agency Karachi Government of Sindh, Pakistan. Time series analysis was considered to understand the chronological behavior of the high concentrations of atmospheric pollutants [5, 9]. The linear regression and Pearson Correlation were applied to see significant positive or negative relations between air pollutants and environmental factors. A simple linear regression model is suitable for the prediction of pollutant variables. Significance of results was verified by F-test in analysis of variance [4, 10]. For statistical analysis, we used Minitab 14 [11].

3. RESULTS AND DISCUSSIONS

Revelation to attention of pollutant is important to study in significant risk to human health [10]. Daily variation of NO, NO_2, NOx and CO concentration of study period is revealed in Figure **1**. The overall concentrations of pollutants at Karachi city are slightly downward trend. Such measurements were carried out to study diverse effect of pollutants. The decreasing trends of pollutant elements NO, NO_2, NOx and CO concentration in the Karachi highlight the significance of overall effect analysis in vehicle emission control measures. Figure **1a** addressed the daily variability in the mean value of NO. The NO slowly decline and shows peak value concentration 61.9ug/m3 in 11/22/2009, Figure **1b** represents daily variation of NO_2 which also slowly decreases. It shows highest peak value of 83.5ug/m3 in 12/9/2009. Similarly Figure **1c** and **d** illustrates peak values of concentrations of NOx (83.939ppb) and CO (1.618mg/m3) in 12/9/2009 and 1/13/2010 respectively.

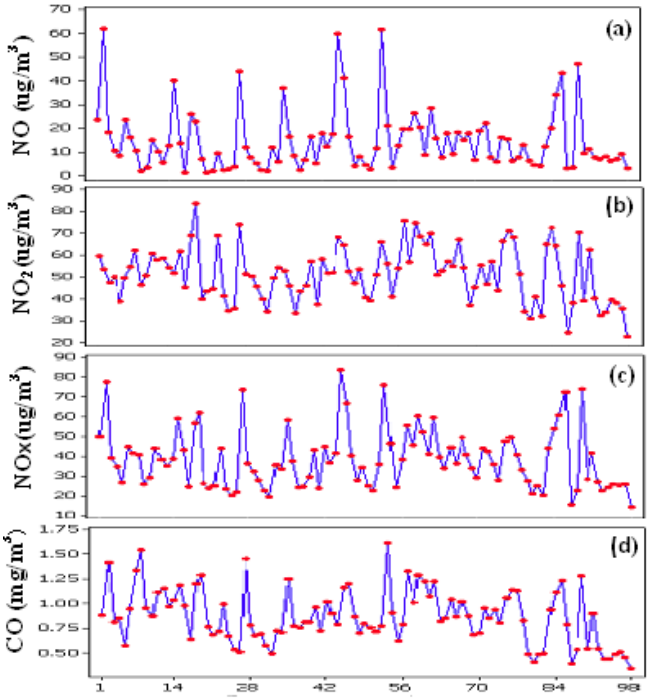

Figure 1: Trend of daily mean variation of (**a**) NO, (**b**) NO_2, (**c**) NO_x and (**d**) CO concentration in Karachi (21/11/2009-27/02/2010).

Since, carbon monoxide (CO) and nitrogen oxides (NOx = NO+NO_2), which are synchronized pollutants

under the National Ambient Air Quality Standards, are harmfully influence human health and biological ecosystems [12].

Figure **2** present the variation of [NO_2] with [NOx] using the observed data from 21/11/2009 to 27/02/2010 and applied a fitted linear regression. Considerable variability is seen among the paired values of NO_2 and NOx with correlation coefficient of 0.794 and statistical summary of results are given in Table **1**. The linear regression line explained that as NO2 increases NOx also increases with positive slop of 0.9543. The relationship is significant because coefficient of determination R^2=63% explained by the regression with F statistic of 163.47, p-value < 0.05 at 95% confident level.

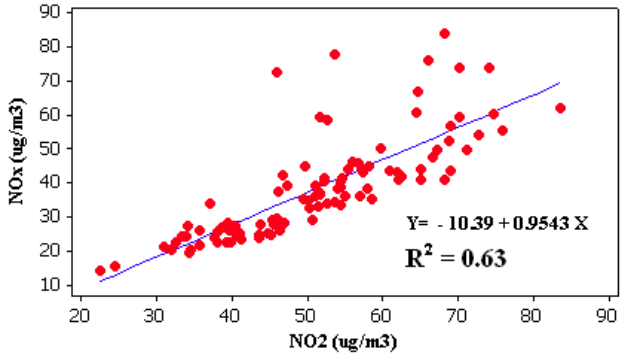

Figure 2: Relationship between mean daily variations of NO_2 with NO_x from (21/11/2009-27/02/2010).

Table 1: Overview of Statistic of Emissions NO_2 and NOx in the Study Period with Parameters of Linear Regression

Predictor	Coef	SE Coef	T	P	
Constant	-10.387	3.945	-2.63	0.010	
NO_2	0.9543	0.0746	12.79	0.000	
S = 9.25875	R^2 = 63.0%		R^2(adj) = 62.6%		
Analysis of Variance					
Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	1	14013	14013	163.47	0.000
Residual Error	96	8230	86		
Total	97	22243			

Figure **3** illustrates the relationship among the paired values of [NO] and [NOx]. The fitted linear regression between them revealed a strong correlation of 0.927 with positive slop of 1.069. The results in Table **2** revealed that as NO increases NOx also increased. The relation can considered well significant because the coefficient of determination fond R^2=86.2% with F statistic of 599.28, p-value 0.00 at 95% confident interval. This proved that it is a strong relation.

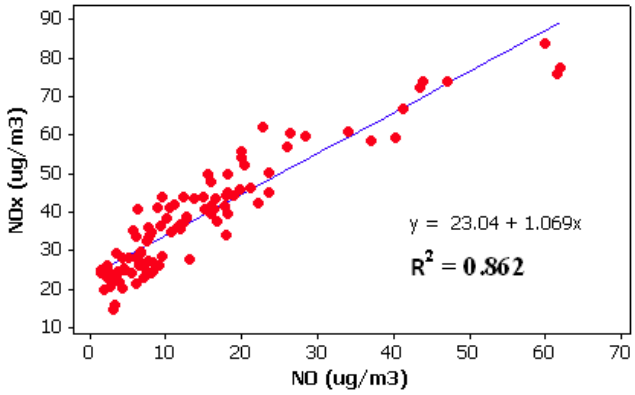

Figure 3: Relationship between mean daily variations of NO with NO_x from (21/11/2009-27/02/2010).

Table 2: Overview of Statistic of Emissions NO and NOx in the Study Period with Parameters of Linear Regression

Predictor	Coef	SE Coef	T	P	
Constant	23.0374	0.8552	26.94	0.000	
NO	1.06888	0.04366	24.48	0.000	
S = 5.65612	R^2 = 86.2%		R^2 (adj) = 86.0%		
Analysis of Variance					
Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	1	19172	19172	599.28	0.000
Residual Error	96	3071	32		
Total	97	22243			

Similarly, we demonstrated how CO dependent on NO_2 concentration. The relationship also described strong positive correlation (R^2=74.2%). The linear regression could explain best relationship among the CO and NO_2 with positive slop of 0.019 (Figure **4**). The linear regression described that as NO_2 increased consequently CO also increased. The results are prevalent in Table **3**. and are well significant as F-statistics is 276.79 with p-value 0.00 (as p<0.05) at 95% confident interval. This shows the relation is well significant.

4. CONCLUSION

The strong concentrations of air pollutants have been proved a serious threat to human health and can

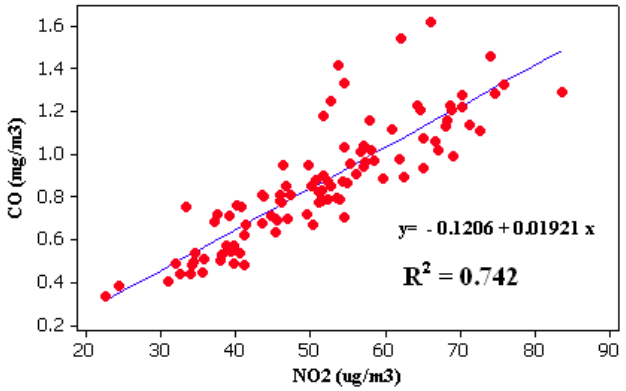

Figure 4: Relationship between mean daily variations of NO_2 with CO from (21/11/2009-27/02/2010).

Table 3: Overview of Statistic of Emissions NO2 and CO in the Study Period with Parameters of Linear Regression

Predictor	Coef	SE Coef	T	P	
Constant	-0.12056	0.06102	-1.98	0.051	
NO_2	0.019206	0.001154	16.64	0.000	
S=0.143201	R^2 = 74.2%		R^2 (adj) = 74.0%		
Analysis of Variance					
Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	1	5.6760	5.6760	276.79	0.000
Residual Error	96	1.9686	0.0205		
Total	97	7.6446			

damage the surrounding environment [5]. This article analyses the concentrations of nitric oxide (NO), nitrogen dioxide (NO_2), nitrogen oxides (NOx) and carbon monoxide(CO) and the required important data taken from Environmental protection agency Karachi Government of Sindh, Pakistan over 98 complete days from 21 November 2009 to 28 February 2010 in winter season. Time series of pollutant concentrations of CO, NO, NO2 and NOx observed during study period at Karachi were considered. The results suggest that the concentrations of pollutant over the interval are slightly decreased and the decreasing trends of toxin elements concentration in the Karachi highlight the significance of overall effect analysis in vehicle emission control measurements. Furthermore, the data have used to explore NO_2 by examining its relation with ambient concentrations of NO, NO_x and CO. Our results confirmed a strong linear relationship between NO_2 and NOx, NO and NO x, NO_2 and CO and the level of pollutants are strongly correlated. The linear regression could be valuable for forecasting and air pollution control policies.

The study will be helpful to understand the chronological behavior of concentrations of atmospheric pollutants which can be further utilized for making policy decisions to control air pollution. Further we will expend this research to study the persistence and anti-persistent behavior of air pollutant using fractal dimension analysis in next communication.

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