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Status and Prediction of Nitrogen Oxides in the Air of Shiraz City, Iran

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Abstract

In the present study, air quality analyses for Nitrogen oxides (NO_X) were conducted in Shiraz, a city in the south of Iran. The measurements were taken over the period from 2011 through 2012 in two different locations to prepare average data in the city. The average concentrations were calculated every twenty-four hours, each month and each season. The results showed that the highest concentration of NO_X occurred generally in the morning while the least concentration was found at mid-night. Monthly concentrations of NO_X showed that the highest value occurred in December, while the least value was recorded in September. The seasonal concentrations showed that the least amounts were in summer, while the highest amounts were found in winter. Unfortunately, most of the time, the concentration of the NO_X showed higher levels than the primary standards of Nitrogen dioxide (0.021 ppm), protecting human health. Relations between air pollutants and some meteorological parameters were calculated statistically using the daily average data. The wind data (velocity, direction), relative humidity, temperature, sunshine periods, evaporation, dew point and rainfall were considered as independent variables. The relationships between the concentration of pollutants and meteorological parameters were expressed by multiple linear regression equations for both annual and seasonal conditions using the SPSS software. The RMSE test showed that among the different prediction models, the stepwise model is the best option.

Keywords: Nitrogen Oxides, Air Pollution, Meteorological Parameters, Regression Model.

1. Introduction

Air sustains life. But the air we breathe is not pure. It contains a lot of pollutants and most of these pollutants are toxic (Sharma, 2001). While developed countries have been making progress during the last century, air quality has been getting much worse especially that in developing countries air pollution exceeds all health standards. For example, in Lahore and Xian (china) dust is ten times higher than health standards (Sharma, 2001).

Nitrogen oxides (NO_x) include different forms of oxides of nitrogen. NO_2 generally derives from emissions of NO (in high temperature). About 95 % of Nitrogen oxides are emitted as NO and 5 % as NO_2. Other oxides are N_2O, N_2O_3 and N_2O_5 which are not so important in air pollution. Among NO_x, NO_2 leads to respiratory problems, therefore NO_2 is considered the most important of the oxides of nitrogen.

Nitrogen dioxide (NO_2) is one of the seven conventional (criteria) pollutants (including SO_2, CO, particulates, hydrocarbons, nitrogen oxides, O_3 and lead). These pollutants produce the highest volume of pollutants in the air and the most serious threat for human health and welfare. The concentration of these pollutants, especially in cities, has been regulated by the Clean Air Act since 1970 (Cunningham and Cunningham, 2002).

Some properties of Nitrogen dioxide (NO_2) include: a reddish brown gas, formed as fuel burnt in cars, a strong oxidizing agent and forms Nitric acid in air. Its Sources are divided into two parts: 1) natural emissions including forest fires, volcanoes, bacteria in the soil, lightening, etc. 2) anthropogenic activities including motor vehicle emissions and power generation. Fuel combustion increases NO_2 production. Half of the emission of HC and NOx in cities comes from Motor vehicles. (Asrari et al., 2007).

The presence of pollutants in the atmosphere, causes a lot of problems, thus the study of pollutant's behavior is necessary. Some of the main health effects of NO_2 include lung and heart problems, NO_2 poisoning, asthma, lowered resistance to infection. Other Effects include damage to plants such as the damages of leaves, retarding photosynthesis activity, chlorosis, damage to various textile fibers, multiplying the photochemical smog problems and those by acid rain (Sharma, 2001).

The status of pollutants' concentration and the effects of meteorological and atmospheric parameters on these pollutants constitute the base for following studies: Ho and Lin (1994) studied semi-statistical models for evaluating the NO_x concentration by considering source emissions and meteorological effects. Moreover, the street levels of NO_x and SPM in Hong Kong have been studied by Lam et al., (1997). In another study, the relationship between monitored air pollutants and meteorological factors, such as wind speed, relative humidity ratio and temperature, was statistically analyzed, using SPSS. According to the results obtained through multiple linear regression analysis, there was a moderate and weak relationship between the air pollutants like the O_3 level and the meteorological factors in Trabzon city during some months (Cuhadaroglu and Demirci, 1997).

Mandal (2000) has shown the progressive decrease of air

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pollution from west to east in Kolkata. Statistical modeling of ambient air pollutants in Delhi has been studied by Chelani et al., (2001). Abdul-Wahab and Al-Alawi (2002) developed a neural network model to predict the tropospheric (surface or ground) ozone concentrations as a function of meteorological conditions and various air quality parameters. The results of this study showed that the artificial neural network (ANN) is a promising method for air-pollution modeling. The observed behavior of pollution concentrations to the prevailing meteorological conditions has been studied for the period from June 13 to September 2, 1994, for the Metropolitan Area of Sao Paulo (Sánchez-Ccoyllo and Andrade, 2002). The results showed low concentrations associated with intense ventilation, precipitation and high relative humidity. While high values of concentrations prevailed due to weak ventilation, absence of precipitation and low relative humidity for some pollutants. Also for predicting CO, Sabah et al., (2003) used a statistical model for carbon monoxide levels.

Elminir (2005) mentioned dependence of air pollutants on meteorology over Cairo in Egypt. The results indicate that wind direction was found to have an influence not only on pollutant concentrations, but also on the correlation between pollutants. As expected, the pollutants associated with traffic were at highest ambient concentration levels when wind speed was low. At higher wind speeds, dust and sand from the surrounding desert was entrained by the wind, thus contributing to ambient particulate matter levels. It was also found that, the highest average concentration for NO_2 and O_3 occurred at humidity ≤ 40 % which is indicative of strong vertical mixing. For CO, SO_2 and PM_{10}, the highest average concentrations occurred at humidity being above 80 %. In another research, data on the concentrations of seven air pollutants (CH_4, NMHC, CO, CO_2, NO, NO_2 and SO_2) and meteorological variables (wind speed and direction, air temperature, relative humidity, and solar radiation) were used to predict the concentration of ozone in the atmosphere using both multiple linear and principal component regression methods (Abdul-Wahab et al., 2005). The results showed that while high temperature and high solar energy tended to increase the day time ozone concentrations, the pollutants NO and SO_2 being emitted to the atmosphere were being depleted. However, the model did not predict the night time ozone concentrations as precisely as it did for day time. Asrari et al., (2007) studied the effect of meteorological factors for predicting co. Similarly, variations in the concentration of co at different times have been shown in this study.

Cesaroni et al. (2012) measured NO_2 at 67 locations in Rome during 1995-1996, and seventy-eight sites in 2007, over three one-week-long periods. To develop LUR models, several land-use and traffic variables were used. NO_2 concentration at each residential address was estimated for a cohort of 684,000 adults. They used Cox regression to analyze the association between the two estimated exposures and mortality. Results showed that the measured and predicted NO_2 values from LUR models, from samples collected twelve years apart, had good agreement, and that the exposure estimates were similarly associated with mortality in a large cohort study.

Li et al., (2014) presented the spatial and temporal variation of Air Pollution Index (API) and examined the relationships between API and meteorological factors over the period between 2001 and 2011 in Guangzhou, China. Relationships were found between API and a variety of meteorological factors. Temperature, relative humidity, precipitation, and wind speed were negatively correlated with API, while the diurnal temperature range and atmospheric pressure were positively correlated with API in the annual condition.

Yoo et al., (2014) mentioned that all of the pollutants show significant negative correlations between their concentrations and rain intensity due to washout or convection. The relative effect of the precipitation on the air pollutant concentrations was estimated to be: $PM_{10} > SO_2 > NO_2 > CO > O_3$, indicating that PM_{10} was most effectively cleaned by rainfall.

Jhun et al., (2015) analyzed hourly O_3 and NOx measurement data between 1994 and 2010 in the continental USA. Nationally, hourly O_3 concentrations decreased by as much as −0.38 ppb/year with a standard error of 0.05 ppb/year during the warm season midday, but increased by as much as +0.30±0.04 ppb/year during the cold season. High O_3 concentrations (≥75th percentile) during the warm season decreased significantly, however, there were notable increases in the cold season as well as warm season nighttime; we found that these increases were largely attributable to NOx decreases as less O_3 is quenched.

Wang et al. (2015) studied air quality in Chongqing, the largest mountainous city in China. Statistical analysis of NO_2 concentrations was conducted over the period from 2002 to 2012, The analysis of Pearson correlation indicated that the concentrations of NO_2 were positively correlated with atmospheric pressure, but were negatively correlated with temperature and wind speed. The analysis of Multi-Pollutant Index (MPI) showed that air quality in Chongqing was serious.

Choi et al., (2017) conducted a nitrogen dioxide (NO_2) exposure assessment with four methods including LUR in the Republic of Korea to compare the model performances, and estimate the empirical NO_2 exposures of a cohort. The LUR models showed high performances in an industrial city in the Republic of Korea, despite the small sample size and limited data. Findings suggest that the LUR method may be useful in similar settings in Asian countries where the target region is small and the availability of data is low.

Statistical modeling of NO_2 was studied in Iranian cities of Ahvaz (Masoudi and Asadifard, 2015), Tehran (Masoudi et al., 2017a) and Isfahan (Masoudi and Gerami, 2018a). According to the results obtained by multiple linear regression analysis for seasonal and annual conditions, there were significant relationships between NO_2 levels and meteorological factors in these cities. Such results between other pollutants and meteorological factors in Shiraz, another Iranian city, were observed: O_3 (Masoudi et al., 2016); CO (Masoudi et al., 2017b) and PM_{10} (Masoudi et al., 2018b).

The presents study exhibits diurnal, monthly and seasonal variations of the concentration of NOx and also a statistical model that is able to predict the amount of NOx. This is based on multiple linear and nonlinear regression techniques. Multiple Regression estimates the coefficients of the linear equations, involving one or more independent variables that best predict the value of the dependent variable (NO_X amount in this study). Accordingly, a large statistical and graphical software package (SPSS, Software Package of Social Sciences, V. 20), that is one of the best known statistical packages has been used (Kinnear, 2002).

2. Materials and Methods

2.1. Study Area

The research area, Shiraz, is the biggest city in the southern part of Iran (Fig. 1). It is located around 29° 30' N and 52º 30' E and the elevation is about 1500 m above the mean sea level. The annual precipitation in Shiraz is about 330 mm. The city of Shiraz has a semi-arid climate, and its residential population amounted to 1,500,000 in 2010. There are lots of cars driven in the city, and also many factories and industrials are built around it. Because of these reasons, Shiraz is one of the most polluted cities in Iran, therefore, there is an urgent need for an ambient air quality analysis to be conducted in this city.

Figure 1. Two photographs from the same place in Shiraz showing impacts of dust pollution during recent years (left one in clean condition and right one in worse condition).

2.2. Data and Methodology

Two available sampling stations in the city, namely Setad and Darvazah-Kazarun, belonging to the Environmental Organization of Iran were selected to represent different traffic loads and activities.

The sampling has been performed every thirty minutes daily for each pollutant during all months of 2011 and 2012. Among the measured data in the two stations, Nitrogen oxides were chosen. Then the averages were calculated for every hour, monthly and seasonally for both stations by Excel. Finally, the averages of data at the two stations were used to show the air pollution situation as diurnal, monthly and seasonal graphs of the concentration of Nitrogen oxides in the city.

studying the correlation of Nitrogen oxides and metrological parameters of the synoptic station of the city was the next step. The metrological parameters studied include: temperature (min., max., and mean), ratio of humidity (min, max), precipitation, sunshine hours, wind direction (max), wind speed (max and mean) and evaporation.

In the next step, the daily average data at the two stations in 2012 was considered as dependent variables in the statistical analysis, while the daily data of the meteorological parameters during this year were selected as independent variables in the SPSS programme. The linear regression equation showed that the concentration of Nitrogen oxides depends on the kind of meteorological parameters and also gives an idea about the levels of this relation. The relationship between the dependent variables and each independent variable should be linear. The significant values in the output are based on fitting a single model. Also, a linear regression equation made for different seasons perhaps show that those relationships are not observed using annual data.

The model for predicting Nitrogen oxides was determined using two multiple regression modeling procedures of the 'enter method' and the 'stepwise method'. In the 'enter method' all independent variables selected are added to a single regression model. In the 'stepwise method' which is better, all variables can be entered or removed from the model depending on the significance. Therefore, only those variables which have more influence on dependent variable are observed in a regression model.

3. Results and Discussion

In Figs. 2, 3, and 4, the diurnal, monthly and seasonal variations in concentration of NOx have been presented. As shown in figure 2, the high concentration of NOx occurs in the morning. Monthly concentration of the NO_x showed that the highest values were in December and the least amounts were recorded in September (Fig. 3). The seasonal concentration of NO_x showed that the highest values were in winter, and that the least amounts were reported in summer (Fig. 4). Unfortunately, all graphs showed that the concentrations of NO_x are higher than the Primary Standards of Nitrogen dioxide (0.021 ppm), recommended by the National Ambient Air Quality Standards (NAAQS) of Iran respectively. These results are almost in good agreement with results obtained regarding other cities including Tehran (Masoudi et al., 2017a), Isfahan (Masoudi and Gerami, 2018a), and Ahvaz (Masoudi and Asadifard, 2015).

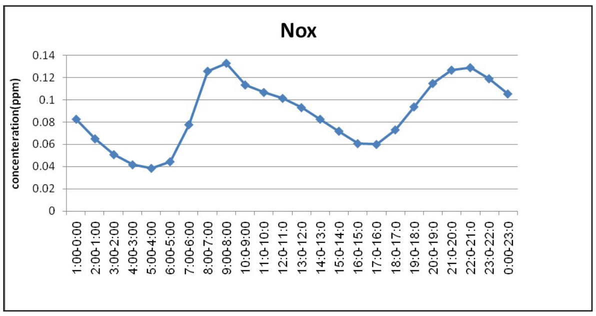

Figure 2. Diurnal variation of Nitrogen oxides' concentrations in Shiraz (2011-2012).

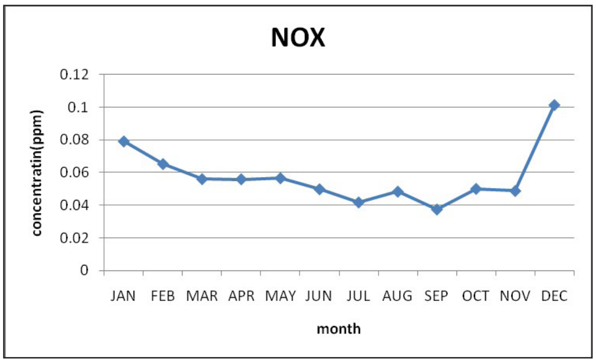

Figure 3. Monthly variation of Nitrogen oxides' concentrations in Shiraz (2011-2012).

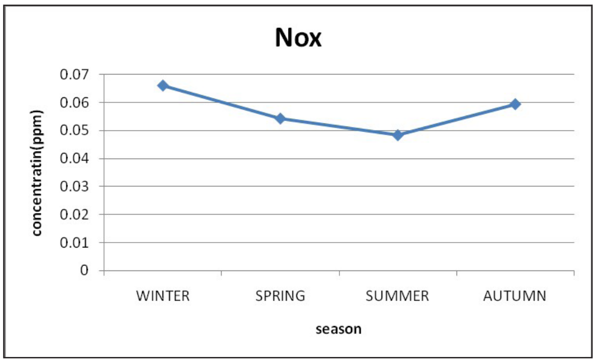

Figure 4. Seasonal variation of Nitrogen oxides' concentrations in Shiraz (2011-2012).

Table 1 shows the relationships between NO_X and other air pollutants. For example, the concentration of NO_X shows a negative correlation with PM and SO_2, O_3, while it shows a positive correlation with NO_2 and CO. NO_X, like NO_2 and CO, is increased when traffic increases, while other negative pollutants are related to other resources like SO_2 whose main source is the industrial activities, or PM_{10} whose main source is the detached soils from western neighbors like Iraq, or ozone related to the increasing of sunlight. These results are almost in good agreement with other results regarding NO_x assessment in other cities including Tehran (Masoudi et al., 2017a), and Isfahan (Masoudi and Gerami, 2018a). The correlation coefficients significant at the 0.05 level are identified with a single asterisk (significant), and those significant at 0.01 level are identified with two asterisks (highly significant).

Table 1. Correlation between air pollutants and ozone.

	CO	PM	NO_2	O_3	SO_2
Pearson Correlation	.145*	-.220**	.895**	-.096	-.402**
Sig. (2-tailed)	.032	.001	.000	.156	.000
N	221	221	221	221	221

Table of analysis of variance (Table 2) shows that both regressions of 'enter' and 'stepwise' methods in annual condition are highly significant, indicating a significant relation between the different variables.

Table 2. Tables of analysis of variance for both regressions of 'enter' (a) and 'stepwise' (b) methods for annual condition.

Analysis of variance (a)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	89568.643	11	8142.604	16.190**	.000
Residual	153396.583	305	502.940		
Total	242965.226	316			

Predictors: (Constant), Rain, Wind direction (max), Wind speed (max), Wind speed (mean), Temperature (max), Temperature (min), Temperature (mean), Sunshine Hours, Ratio of Humidity (min), Ratio of Humidity (max), Ratio of Humidity (mean), Evaporation.
Dependent Variable: NO_X

Analysis of variance (b)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	87652.374	7	12521.768	24.912**	.000
Residual	155312.852	309	502.631		
Total	242965.226	316			

Predictors: (Constant), Sunshine Hours, Ratio of Humidity (min), Ratio of Humidity (max), Wind direction (max)
Dependent Variable: NO_X

Table 3 presents the coefficients of NO_X pollution model and regression lines for both the enter and stepwise methods in annual conditions. Regression coefficients, standard errors, standardized coefficient beta, t values, and two-tailed significance level of t are presented in the Tables.

Table 3. Coefficients of NO_X pollution model and regression lines for both enter (a) and stepwise (b) methods for annual conditions.

Coefficients (a)

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	61.898	17.870		3.464	.001
Temperature (min)	-3.463	.706	-.948	-4.902**	.000
Temperature (max)	-1.336	.703	-.442	-1.901	.058
Temperature (mean)	1.639	.703	.512	2.332*	.020
Ratio of Humidity (min)	.879	.238	.411	3.693**	.000
Ratio of Humidity (max)	-.479	.140	-.338	-3.415**	.001
Rain	-.352	.409	-.050	-.860	.390
Sunshine Hours	1.021	.728	.099	1.402	.162
Evaporation	1.909	.901	.284	2.118*	.035
Wind speed (max)	1.568	.885	.124	1.771	.078
Wind direction (max)	-.005	.015	-.016	-.322	.748
Wind speed (mean)	1.912	1.847	.075	1.035	.301

Dependent Variable: NO_X

Coefficients (b)

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	75.492	15.661		4.820	.000
Temperature (max)	-1.326	.664	-.439	-1.998*	.047
Evaporation	2.106	.889	.313	2.369*	.018
Temperature (min)	-3.453	.675	-.945	-5.114**	.000
Wind speed (max)	2.019	.651	.159	3.101**	.002
Temperature (mean)	1.526	.690	.477	2.211*	.028
Ratio of Humidity (max)	-.486	.138	-.343	-3.513**	.001

Dependent Variable: NO_X

The linear regression equations show that NO_X pollution depends on the meteorological parameters, and also gives an idea about the levels of relations. The linear model equations after using the 'enter method' and 'stepwise method' for the annual condition are:

- NO_X amount (ppb) using 'enter method' for annual condition = 61.898+ (-3.463) $Temperature_{(min)}$ + (-1.336) $Temperature_{(max)}$ + (1.639) $Temperature_{(mean)}$ + (0.879) Ratio of $humidity_{(min)}$ + (-0.479) Ratio of $Humidity_{(max)}$ + (-0.352) Rain + (1.021) Sunshine Hours + (-0.005) Wind $direction_{(max)}$ + (1.568) Wind $speed_{(max)}$ + (1.912) Wind $speed_{(mean)}$ + (1.909) Evaporation R= 0.607 (significant at 0.01)
- NO_X amount (ppb) using 'stepwise method' for annual condition = 75.492 + (2.019) Wind $speed_{(max)}$ + (-0.486) Ratio of $Humidity_{(max)}$ + (-1.326) $Temperature_{(max)}$ + (-3.453) $Temperature_{(min)}$ + (1.526) $Temperature_{(mean)}$ + (2.106) Evaporation R= 0.601 (significant at 0.01)

Results of the linear regression model show that the ratio of humidity (max), $temperature_{(max)}$ and $temperature_{(min)}$ have reverse effect on the concentration of NO_X. Accordingly, when these parameters increase, the concentration of NO_X decreases. While, when Evaporation, wind $speed_{(max)}$ and $temperature_{(mean)}$ increase the concentration of NO_X significantly increases (Table 3b). Other meteorological parameters show different effects on NO_X amounts although these results are not significant. For example, rainfall has reverse effects on the concentration of NO_X (Table 3a). These results are almost in good agreement with other results regarding NO_x measurements in other cities like Tehran (Masoudi et al., 2017a) and Isfahan (Masoudi and Gerami, 2018a) and Ahvaz (Masoudi and Asadifard, 2015). In fact, some of these events happen in real conditions. The increasing of rainfall, wind speed and temperature (inversion happens in low temperatures) usually decreases most of air pollutants (Asrari et al., 2007).

The values and significance of R (multiple correlation coefficient) in both equations show the capability of them to predict the NO_X amount. The amount of Adjusted R^2 in both equations is almost 0.346 showing that different parameters used can calculate almost 35 % variability of NO_X. This result indicates predicting most of air pollutants such as NO_X, taking into consideration the consumption of fossil fuel especially in motor vehicles. Half of emission of (VOC) Hydrocarbons and NOx in cities is produced by motor vehicles. Automobile exhausts is responsible for 75 % of the total air pollution by releasing poisonous gases of CO (77 %), NOx (8 %) and Hydrocarbons (14 %) (Sharma, 2001). On the other hand, R in the enter method (0.607) is almost equal to that in the stepwise method (0.601), showing no difference. Therefore, the second equation that is based on the stepwise method can be used to predict NO_X in the city instead of using the first equation which needs more data. On the other hand, the fact that there is no difference between the two R values indicates that the excluded variables in the second equation have less effect on the measurement of NO_X in the city.

Beta in Table 3 shows that those independent variables (meteorological parameters) have more effect on dependent variables (NO_X). Beta in Table 3 shows a highly significant effect of some variables like temperature compared to other meteorological parameters for measuring NO_X which is close to the results of Tehran (Masoudi et al., 2017a) and Isfahan (Masoudi and Gerami, 2018a) and Ahvaz (Masoudi and Asadifard, 2015). Parameter Sig (P-value) from Table 3 shows the degree of relation between NO_X and meteorological parameters. For example, Table 3a shows that evaporation has a higher effect on NO_X than the sunshine hours.

On the other hand, in Table 4, the linear regression equations of NO_X amount are presented for the enter and stepwise methods in different seasonal conditions. Almost all of the models except the autumn model of the enter method are significant. Stepwise methods show that those meteorological parameters are extremely important during these seasons for estimating the pollution. Among the models, the summer models have the highest R, while the R of the autumn models shows the least. These results are slightly different from the results of Tehran (Behzadi and Sakhaei, 2014) and Isfahan (Masoudi and Gerami, 2018a), and Ahvaz (Masoudi and Asadifard, 2015). R in the summer and winter models are higher than in the annual models, also indicating that relations between the pollutant and meteorological parameters are stronger than the whole year during these seasons.

Table 4. NO_X amount (ppb) using the enter and stepwise methods for different seasonal conditions.

season	enter method	R	stepwise method	R
Winter	= 21.446 + (3.431) Tmax +(-3.618) Tmin + (-.296) WSmean +(-.308) WSmax + (-.011) WDmax + (.021) RHmax + (.427) RHmin + (-.023) R + (-.909) SH	.712 (significant at 0.01)	= 5.867 + (.577) RHmin + (-3.655) Tmin + (3.552) Tmax + (-2.793) E	.700 (significant at 0.01)
Spring	= 49.457 + (.815) Tmean + (.599) Tmax + (-1.834) Tmin + (-2.101) WSmean + (.674) WSmax + (-.011) WDmax + (.035) RHmax + (.094) RHmin + (-2.022) R + (-.479) SH	.556 (significant at 0.01)	= 57.417 + (.883) Tmean + (-1.513) Tmin + (-1.302) E	.505 (significant at 0.05)
Summer	= -180.905 + (3.239) Tmax + (.672) Tmin + -(1.590) WSmean + (2.099) WSmax + (-.025) WDmax + (.003) RHmax + (.217) RHmin + (2.766) SH	.745 (significant at 0.01)	= -184.583 + (3.587) Tmax + (4.262) E + (2.972) SH	.724 (significant at 0.01)
Autumn	= .842 + (.030) Tmax + (-.016) Tmin + (-.084) WSmean + (.060) WSmax + (.000) WDmax + (-.001) RHmax + (.002) RHmin + (-.011) R + (-.042) SH	.448 (not Significant)	= .905 + (.036) WSmax	.278 (significant at 0.05)

where Tmean is the Temperature (mean), Tmax is the Temperature (max), Tmin is the Temperature (min), WSmean is the Wind speed (mean), WSmax is the Wind speed (max), WDmax is the Wind direction (max), RHmean is the Ratio of Humidity (mean), RHmax is the Ratio of Humidity (max), RHmin is the Ratio of Humidity (min), SH is the Sunshine Hours, R is the Rainfall, and E is the Evaporation

To test which annual model is better to use, RMSE (Root Mean Square of Error) is calculated for different linear models of the enter and stepwise methods. Predicted amounts using the different annual models for thirty days during 2011 are calculated and compared with the observed data during those days using the RMSE equation:

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}(O_{obs} - O_{cal})^2}{n}} \quad \text{.......} (1)$$

where O_{obs} is the observed NO_x value, and O_{cal} is the predicted NO_x value using model

The values of RMSE in both linear models of enter (39.32) and stepwise (37.34) methods show the capability of the stepwise model to predict NO_x amount compared to the enter model. This result is in agreement with the results of some studies conducted on other Iranian cities including Tehran (Masoudi et al., 2017a), Isfahan (Masoudi and Gerami, 2018a) and Ahvaz (Masoudi and Asadifard, 2015) and also other studies of other pollutants in the Shiraz city such as O_3 (Masoudi et al., 2016), CO (Masoudi et al., 2017b) and PM_{10} (Masoudi et al., 2018b). The results indicate predicting most of air pollutants like NO_x when taking into consideration only the linear models of the stepwise method which need less data in addition to the fact that its calculation is easier than the enter model.

4. Conclusions

Nitrogen oxides are listed among the seven conventional (criteria) pollutants (including SO2, CO, particulates, hydrocarbons, nitrogen oxides, O3 and lead). In the current research, air quality analyses for Shiraz were conducted for NOx. Shiraz is one of the highly polluted cities in Iran. Thus, there is an urgent need for conducting similar studies to analyze air quality in this city. The results of the current research showed that in the Enter and Stepwise models, there were significant relationships between NOx and some meteorological parameters. The amount of R for both models was highest during the summer. From the final part of the study, which uses the RMSE (Root Mean Square of Error) value, it can be concluded that the Stepwise model is more suitable for this pollutant. Finally, it can be said that there is a significant relationship between the amount of air pollutants and atmospheric parameters that can be used to predict the amount of contaminants in the coming years. Also, the results almost all times showed that the concentration levels of NOx were higher than the primary standards of NOx exhibiting unhealthy conditions.

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