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Status and prediction of carbon monoxide as an air pollutant in Ahvaz City, Iran

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ABSTRACT

In the present study, air quality analyses were conducted for carbon monoxide (CO) in Ahvaz, a city in the south of Iran. The measurements were taken from 2009 through 2010 in two different locations to prepare average data in the city. The average concentrations calculated for every 24 hours, each month and each season showed that the highest CO concentration occurs generally in the nighttime, while the least was found at in the midday. Monthly CO concentrations showed the highest values in May and June, while the least in January and February. The seasonal concentrations showed the highest amounts in the spring. Then Relations between the air pollutant and some meteorological parameters were calculated statistically using the daily average data. The wind data (velocity, direction), relative humidity, temperature, sunshine periods, dew point and rainfall were considered as independent variables. The level relationships between pollutant concentration and meteorological parameters were expressed by multiple linear and nonlinear regression equations for both annual and seasonal conditions using SPSS software. RMSE test showed that among different prediction models, stepwise model is the best option.

Key words: Air pollution, Carbon monoxide, Ahvaz, Meteorological Parameters, Regression model.

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 in developing countries and air pollution exceeds all health standards (Sharma 2001). Carbon monoxide (CO) is one of the seven conventional (criteria) pollutants (including CO, SO_2, 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. Concentration on these pollutants, especially in cities, has been regulated by Clean Air Act since 1970 (Cunningham & Cunningham 2002). CO pollution occurs primarily from emissions produced by fossil fuel powered engines, including motor vehicles and non-road engines and vehicles (such as construction equipment and boats). Higher levels of CO generally occur in areas with heavy traffic congestion. The presence of pollutants in the atmosphere, causes a lot of problems, thus the study of pollutant' behavior is necessary (Asrari *et al.* 2007). Status of pollutant concentrations and effects of meteorological and atmospheric parameters on these pollutants compose the base of following studies: In a 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, for some months there was a moderate and weak relationship between the air pollutants like CO level and the meteorological factors in Trabzon city

(Cuhadaroglu & Demirci 1997). Mandal (2000) has shown the progressive decrease of air pollution from west to east in Kolkata. Statistical modeling of ambient air pollutants in Delhi has been studied by Chelani *et al.* (2001). 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 & Andrade 2002). Results showed that low concentrations were associated with intense ventilation, precipitation and high relative humidity, While high values 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. Elminir (2005) mentioned dependence of air pollutants on meteorology over Cairo in Egypt.

The results hint that, wind direction was found to have an influence not only on pollutant concentrations but also on the correlation between pollutants. Asrari *et al.* (2007) studied the effect of meteorological factors for predicting CO As well as variations in concentration of CO in different times. Ashrafi & Orkomi (2014) tried to demonstrate a significant correlation between air pollutant concentrations and meteorological parameters, by the study of the atmospheric conditions in an air pollution episode. Li *et al.* (2014) presented the spatial and temporal variation of air pollution index (API) and examined the relationships between API and meteorological factors during 2001–2011 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 diurnal temperature range and atmospheric pressure were positively correlated with this index 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. Statistical modeling of CO was studied in Iranian cities of Esfahan (Masoudi & Gerami 2017) and Shiraz (Masoudi *et al.* 2017b). According to the results obtained by multiple linear regression analysis for seasonal and annual conditions, there were significant relationships between CO and meteorological factors in these cities. Such results between other pollutants and meteorological factors in other Iranian cities were observed such as: NO_2 in Ahvaz (Masoudi & Asadifard 2015), PM_{10} in Tehran (Masoudi *et al.* 2016b), SO_2 in Ahvaz (Masoudi *et al.* 2017a) and ozone in Ahvaz (Masoudi *et al.* 2014a), Tehran (Masoudi *et al.* 2014b) and Shiraz (Masoudi *et al.* 2016a). The paper presents diurnal, monthly and seasonal variations of CO concentration and also a statistical model enabling to predict amount of CO based on multiple linear and nonlinear regression techniques. Multiple regression estimates the coefficients of the linear and nonlinear equations, involving one or more independent variables for best predicting the value of the dependent variable, CO amount. So that, a large statistical and graphical software package (SPSS, Software Package of Social Sciences, V. 20), has been used as one of the best known statistical packages (Kinnear 2002).

MATERIALS AND METHODS

Study Area

The research area, Ahvaz, capital of Khuzestan Province, is the biggest city in the south-western part of Iran (Fig. 1) located around 31° 19' N and 48º 40' E and about 20 m above the mean sea level. Annual precipitation of Ahvaz is about 230 mm. It has arid climate and its residential population was found to be 1,425,000 in 2006. Ahvaz is consistently one of the hottest cities on the planet during the summer, with summer temperatures regularly at least 45°C, sometimes exceeding 50°C with many sand- and dust storms common during the summer period, while in winters the minimum temperature could fall around +5°C. Ahvaz is built on the banks of the Karun River and is situated in the middle of Khuzestan Province. Iraq attempted to annex Khuzestan and Ahvaz in 1980, resulting in the Iran–Iraq War (1980–1988).

Ahvaz was close to the front lines and was suffered severe damages during the War. There are lots of cars driven in the city and also many factories and industrials around it. So, Ahvaz is one of the most polluted cities in Iran and needs to carry out an ambient air quality analysis in this city. Fig. 1 showed the location of Ahvaz city in Iran.

Fig. 1. Location of Ahvaz city in Iran.

Recently, Ahvaz is considered as the worst polluted city of the world according to a survey by the World Health Organization in 2011 because of high concentration of dust during all the year (Guinness World Records, 2013). Increasing amount of dust (Fig. 2) can cause different problems such as increasing number of cancer and lung damages.

Fig. 2. Two photographs from the same place in Ahvaz showing impacts of dust pollution during recent years (left one in clean condition and right one in worse condition).

Two available sampling stations in the city called, Administration and Naderi, belong to Iranian Environmental Organization were selected to represent different traffic loads and activities. Fig. 3 show the location of the two sampling stations for measuring CO in Ahvaz city and the meteorological station as well as pollution centers such as steel industries and also entrance of dust storm toward the city. The sampling has been performed every 30 minutes daily for each pollutant during all months of 2009 and 2010. Among the measured data in the two stations, CO was chosen. Then the averages were calculated for every hour, each month and each season for the both stations by Excel software. Finally data averages at two stations were used to show air pollution situation as diurnal, monthly and seasonal graphs of concentration of CO in the city. Studying correlation of CO and metrological parameters of synoptic station of the city was the next step. The metrological parameters studied include: temperature (min & max), humidity (min & max), precipitation, sunshine, wind direction, wind speed and evaporation. In the next step, daily average data at two stations in 2010 was considered as dependent variable for statistical analysis, while daily data of meteorological parameters during this year were selected as independent variables in SPSS program. Hence, the multiple regression equations showed that the CO concentration 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 one should be linear.

The significant values in output are based on fitting a single model. Table 1 showed the information and details of the meteorological parameters at Ahvaz in 2010. Also linear regression equation, measured for different seasons may show those relationships which are not observed using annual data.

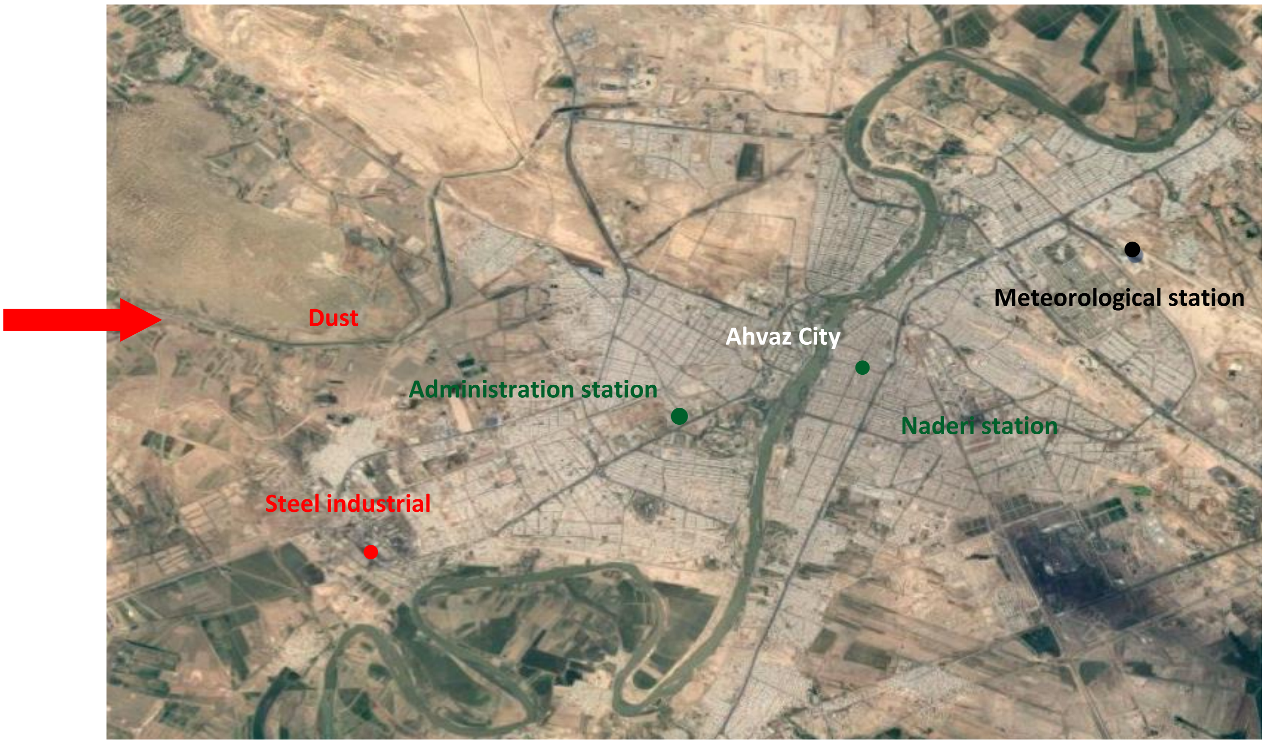

Fig. 3. Location of two sampling stations and the meteorological station in Ahvaz city.

Table 1. Details about the average meteorological parameters per months at Ahvaz in 2010.

Temperature (°C)			Ratio of Humidity (%)			Rain	Wind	
Max	Min	Mean	Max	Min	Mean	(mm)	Direction	Speed (m/s)
39.5	15.6	22.44	63.3	21.01	42.15	6.4	245	10.8

Some options are available in this software; these options apply when the 'enter', 'forward', 'backward', or 'stepwise' variable selection method has been specified. Method selection allows us to specify how independent variables are entered into the analysis. Using different methods, you can construct a variety of regression models from the same set of variables. The model for predicting CO was determined using two multiple regression modeling procedures of 'enter method' and 'stepwise method'. In 'enter method' all independent variables selected are added to a single regression model. In 'stepwise' which has better performance, all variables can be entered or removed from the model depending on the significance. Therefore, only those variables are observed in a regression model which have more influences on dependent variable.

RESULTS AND DISCUSSION

In Figs. 4, 5 and 6, the diurnal, monthly and seasonal variations in CO concentration have been presented. As shown in Fig. 4, the high CO concentration occurs in the night time. Monthly concentration of the CO showed the highest values in May and June and the least amounts in February (Fig. 5). Seasonal concentration showed the highest values in spring and the least in winter (Fig.6). Fortunately, all graphs showed that the CO concentrations are lower than primary standards of CO (9 ppm) recommended by National Ambient Air Quality Standards (NAAQS) of USA and Iran, protecting human health. These graphs show almost annual and monthly but not hourly conditions, while this amount is the primary standard for latter one. Therefore, the real annually and monthly standard should be less than this amount. Hence, it is assumed that some of these amounts in the figures are higher than the real standards, exhibiting unhealthy condition. These results are almost in good agreement with other results regarding hourly variation of CO assessment in other Iranian cities such as Shiraz (Ordibeheshti & Rajai poor 2014), Esfahan (Gerami 2014) and Tehran (Behzadi & Sakhaei 2014) but differ in their monthly and seasonal graphs. Table 2 shows the relationships between CO and other air pollutants. The CO concentration, for example, shows negative correlation with NO_2, PM_{10}, SO_2 and O_3, while positive correlation with NOx, although it is not significant.

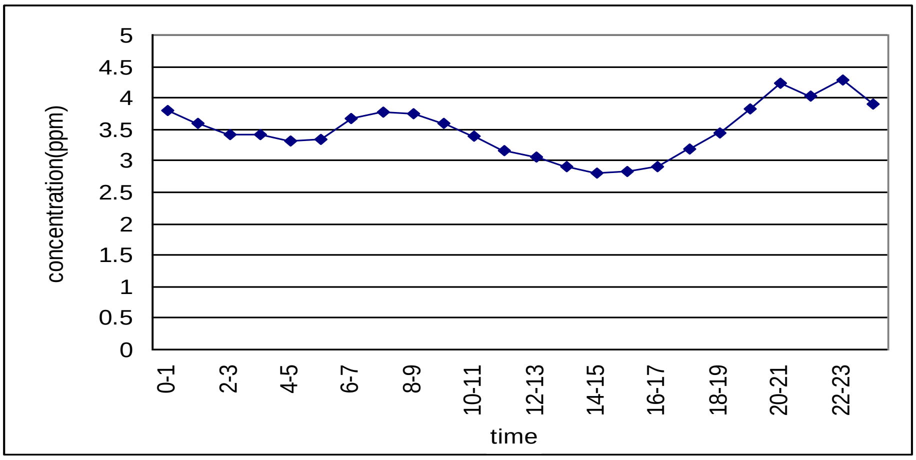

Fig. 4. Diurnal variation of carbon monoxide concentration in Ahvaz (2009-2010).

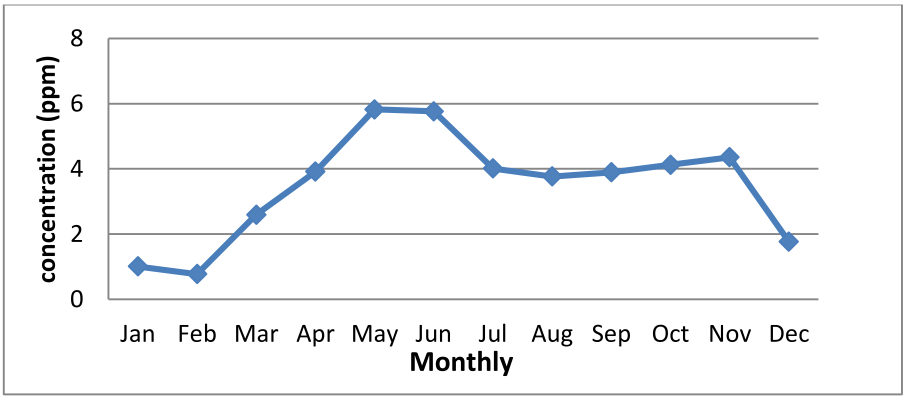

Fig. 5. Monthly variation of carbon monoxide concentration in Ahvaz (2009-2010).

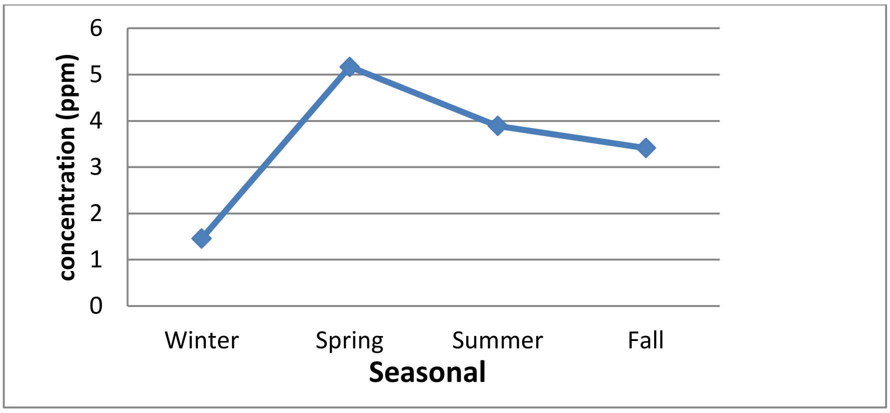

Fig. 6. Seasonal variation of carbon monoxide concentration in Ahvaz (2009-2010).

CO is elevated by increasing in traffic, while other pollutants with negative relationship, are associated with other resources such as SO_2, which its main source is industrial activity, or PM_{10} driven from detached soils of western neighbor countries such as Iraq, or ozone concerning to increasing of sunlight. These results are almost in good agreement with CO assessment in other Iranian cities like Shiraz (Ordibeheshti & Rajai poor 2014), Esfahan (Gerami 2014) and Tehran (Behzadi & Sakhaei 2014). 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 of analysis of variance (Table 3) shows that both regressions of 'enter' and 'stepwise' methods for annual condition, are highly significant, indicating a significant relationship between the different variables.

Table 2. Correlation between carbon monoxide and other air pollutants.

	NO_2	NO_x	O_3	PM_{10}	SO_2
Pearson Correlation	-0.070	0.050	-0.399**	-0.091	-0.580**
Sig. (2-tailed)	0.240	0.404	0.000	0.118	0.000
N	286	286	298	298	298

Table 3. 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	1046.576	10	104.658	6.859**	.000
Residual	4379.313	287	15.259		
Total	5425.889	297			

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

Analysis of variance (b)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	914.033	2	457.016	29.881**	.000
Residual	4511.857	295	15.294		
Total	5425.889	297			

Predictors: (Constant), Wind speed (max), Ratio of Humidity (avg.)
Dependent Variable: CO

Table 4 demonstrates the coefficients of Co pollution model and regression lines for both enter and stepwise methods in annual condition. Regression coefficients, standard errors, standardized coefficient beta, t values, and two-tailed significant level of t have been shown in the Table.

Table 4. Coefficients of carbon monoxide pollution model and regression lines for both enter (a) and stepwise (b) methods for annual condition.

Coefficients (a)

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	4.376	3.314		1.320	0.188
Temperature (max)	0.148	0.110	0.352	1.345	0.180
Temperature (min)	-0.170	0.124	-0.311	-1.368	0.172
Ratio of Humidity (max)	-0.718	0.463	-4.350	-1.552	0.122
Ratio of Humidity (min)	-0.681	0.460	-2.799	-1.479	0.140
Ratio of Humidity (mean)	1.347	0.925	6.577	1.456	0.147
Rain	0.097	0.095	0.060	1.019	0.309
Sunshine Hours	0.052	0.089	0.045	0.584	0.559
Evaporation	0.031	0.100	0.042	0.307	0.759
Wind direction (max)	0.004	0.004	0.072	1.136	0.257
Wind speed (max)	-0.178	0.078	-0.130	-2.291*	0.023

Dependent Variable: carbon monoxide

Coefficients (b)

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	8.682	0.699		12.421	.000
Ratio of Humidity (mean)	-0.085	0.011	-0.416	-7.656**	.000
Wind speed (max)	-0.199	0.075	-0.145	-2.669**	.008

Dependent Variable: carbon monoxide

The linear regression equations show that the CO pollution depends on the meteorological parameters and also give an idea about the level of relationships.

The linear model equations after using 'enter method' and 'stepwise method' for annual condition are:

CO amount (ppm) using 'enter method' for annual condition = 4.376 + (-0.17) Temperature $_{(min)}$ + (0.148) Temperature $_{(max)}$ + (-0.681) Ratio of Humidity $_{(min)}$ + (-0.718) Ratio of Humidity$_{(max)}$ + (1.347) Ratio of Humidity$_{(mean)}$ + (0.097) Rain + (0.052) Sunshine Hours + (0.004) Wind direction$_{(max)}$ + (-0.178) Wind speed$_{(max)}$ + (0.031) Evaporation R= 0.439 (significant at 0.01)

CO amount (ppm) using 'stepwise method' for annual condition = 8.682 + (-0.085) Ratio of Humidity $_{(mean)}$ + (-0.199) Wind speed $_{(max)}$ R= 0.410 (significant at 0.01)

Results of regression model show that ratio of humidity (avg.) and wind speed (max) have reverse effect on CO concentration. So that, by elevating these parameters, the CO concentration significantly decreases (Table 4b). While, by elevating evaporation and temperature (max), the CO arises, although these results are not significant (Table 4a). These results are almost in good agreement with CO measurements in other Iranian cities such as Tehran (Behzadi & Sakhaei 2014), Esfahan (Gerami 2014) and Shiraz (Ordibeheshti & Rajai Poor 2014) and other regions (Elminir 2005; Li *et al.* 2014). Actually some of these events happen in real condition. Increasing in rainfall, wind speed and temperature (inversion happens in low temperatures) usually decrease most of air pollutants (Asrari *et al*. 2007).

The values and significance of R (multiple correlation coefficient) in both equations show capability of them in predicting CO amount. The amount of Adjusted R^2 in enter model is 0.193 and in stepwise model is 0.168 showing that different parameters used can calculate almost 18% CO variability. This result indicates predicting most of air pollutants such as CO. We should take into consideration consumption of fossil fuel especially motor vehicles. Half of emission of (VOC) hydrocarbons and NOx in cities produces by motor vehicles. The automobile exhaust produces 75% of total air pollution, releasing poisonous gases such as CO (77%), NOx (8%) and hydrocarbons (14%) (Sharma 2001). On the other hand, R in enter method (0.47) is equal to stepwise method (0.46), showing no difference. Therefore, second equation based on stepwise method can be used to predict CO in the city, instead of using first equation which needs more data. On the other hand, no difference between the two R values indicates that the excluded variables in second equation have less effect on measuring CO in the city.

Beta in Table 4 shows those independent variables (meteorological parameters) which have more effect on dependent variable (CO). The beta in the both parts of Table 4 shows a highly significant effect of some variables such as the ratio of humidity, compared to other meteorological parameters for measuring the CO which is almost similar to the results of Masoudi *et al.* (2014) for ozone. For this city which is beside the Persian Gulf, it seems that this factor should have more effect compared to other meteorological parameters. Parameter sig. (P-value) from Table 4 shows relationship value between CO and meteorological parameters. For example, Table 3a shows that wind speed has higher relationship than wind direction on CO level.

On the other hand, in Table 5 the linear regression equations of CO level are presented for both enter and stepwise methods in different seasonal conditions. all of the models except summer models are significant which is close to the results of Masoudi & Gerami (2017) and Masoudi *et al.* (2017b). Stepwise methods show those meteorological parameters which are most important during these seasons for estimating the pollution. Among the models, winter models have the highest R, while R of summer model shows the least. R amounts in autumn and winter models are higher than in annual model, also indicating that relationships between the pollutant and meteorological parameters are stronger than other conditions during these seasons. These results are almost in good agreement with other results concerning to the CO assessments in different seasonal conditions obtained from other Iranian cities such as Tehran (Behzadi & Sakhaei 2014) and Esfahan (Gerami 2014) but differ a little from the results in Shiraz (Ordibeheshti & Rajai Poor 2014).

Also the nonlinear multiple regression equation of CO level using parameters of linear stepwise method for annual condition is calculated which is not significant:

CO concentration (ppb) using nonlinear regression for annual condition = -4814.783 LN (Ratio of Humidity$_{(avg)}$) + 4.77+ (-0.104) wind speed+ (-0.001) wind speed ^{2}+ (0.107) wind speed ^{3}

R^2= 0.004.

For validation of the models and to test which annual model is better to use, RMSE (Root Mean Square of Error) is calculated for different linear models of enter and stepwise and nonlinear model. Predicted amounts using the different annual models for 30 days (or 30 data) during 2010 are calculated and compared with observed data during those days using RMSE equation:

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}(O_{obs} - O_{pre})^2}{n}}$$

O_{obs}: observed CO value O_{Pre}: predicted CO value using model

The values of RMSE in both linear models of enter (15.23) and stepwise (4.45) show capability of them in predicting CO level compared to nonlinear model value (17.68). This result which is similar to the results of Masoudi & Asadifard (2015), Masoudi & Gerami (2017) and Masoudi *et al.* (2014a, 2014b, 2016a, 2016b, 2017a and 2017b), indicates that for predicting most of air pollutants such as CO, we may take into consideration only linear models of stepwise which need less data compared to enter model and also its calculation is easier than nonlinear model.

Table 5. Carbon monoxide amount (ppm) using two methods of enter and stepwise for different seasonal condition.

season	enter method	R	stepwise method	R
Spring	= -0.819 + (-0.264) Temperature$_{(min)}$+ (0.448) Temperature$_{(avg)}$ + (-0.874) Ratio of Humidity $_{(min)}$ + (-0.852) Ratio of Humidity$_{(max)}$ + (1.691) Ratio of Humidity$_{(avg)}$ + (0.524) Rain + (0.266) Sunshine Hours + (-0.003) Wind direction$_{(max)}$ + (-0.486) Wind speed$_{(max)}$ + (0.155) Evaporation	0.455 (significant at 0.05)	= -5.194 + (0.252) Temperature$_{(max)}$ + (0.307) Sunshine Hours	0.405 (significant at 0.05)
Summer	= 1.115 + (-0.078) Temperature$_{(min)}$ + (0.087) Temperature$_{(max)}$ + (-0.907) Ratio of Humidity $_{(min)}$ + (-0.884) Ratio of Humidity$_{(max)}$ + (1.768) Ratio of Humidity$_{(avg)}$ + (0.075) Sunshine Hours + (0.002) Wind direction$_{(max)}$ + (-0.170) Wind speed$_{(max)}$ + (0.098) Evaporation	0.367 (not significant)		Not prepared by software showing no significance relationship
Autumn	= 17.474 + (-0.443) Temperature$_{(min)}$+ (0.117) Temperature$_{(max)}$ + (-0.904) Ratio of Humidity $_{(min)}$ + (-0.948) Ratio of Humidity$_{(max)}$ + (1.659) Ratio of Humidity$_{(avg)}$ + (0.075) Rain + (-0.143) Sunshine Hours + (0.012) Wind direction$_{(max)}$ + (-0.082) Wind speed$_{(max)}$ + (0.035) Evaporation	0.563 (significant at 0.05)	= 23.328 + (0.216) Ratio of Humidity$_{(avg)}$ + (0.340) Temperature$_{(avg)}$	0.486 (significant at 0.05)
Winter	= 0.252 + (-0.013) Temperature$_{(min)}$+ (0.023) Temperature$_{(max)}$ + (0.093) Ratio of Humidity $_{(min)}$ + (0.111) Ratio of Humidity$_{(max)}$ + (-0.193) Ratio of Humidity$_{(avg)}$ + (0.004) Rain + (-0.012) Sunshine Hours + (-0.001) Wind direction$_{(max)}$ + (-0.122) Wind speed$_{(max)}$ + (0.004) Evaporation	0.7 (significant at 0.01)	= 0.154 + (-0.001) Wind direction$_{(max)}$ + (-0.125) Wind speed$_{(max)}$ + (0.012) Ratio of Humidity$_{(max)}$ + (0.019) Temperature$_{(max)}$	0.688 (significant at 0.05)

CONCLUSION

This study was about CO pollutant. Ahvaz is one of the most polluted cities in Iran and also in the world. Results showed significant relationships between CO and some meteorological parameters. Based on these relationships, we prepared different multiple linear and nonlinear regression equations for CO in annual and seasonal conditions. Results showed that among different prediction models, stepwise was the best model for status and prediction. Results in the late night and spring, as well as May and January showed that the concentration levels of CO were upper than primary standards of CO exhibiting unhealthy condition.

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وضعیت و پیش بینی مونوکسید کربن به عنوان آلاینده هوا در شهر اهواز، ایران

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چکیده

در پژوهش فوق، کیفیت هوا برای آلاینده‌ی مونوکسید کربن (CO) در شهر اهواز که در جنوب ایران واقع شده است، بررسی شد. برای تهیه داده‌های میانگین جهت اندازه گیری‌ها، از سال ۲۰۰۹ تا ۲۰۱۰ در دو مکان مختلف در شهر اهواز استفاده شد. غلظت میانگین آلاینده مونوکسید کربن برای هر ۲۴ ساعت، هر ماه و هر فصل محاسبه شد که حاکی از این است که بیشترین غلظت مونوکسید کربن به طور کلی در شب رخ می‌دهد، این در حالی است که حداقل غلظت این آلاینده هم در ظهر مشاهده می‌شود. غلظت ماهانه مونوکسید کربن در ماه‌های مه و ژوئن بالاترین میزان و در ماه ژانویه و فوریه کمترین میزان را نشان داد. بیشترین غلظت فصلی آلاینده مونوکسیدکربن مربوط به فصل بهار بود. سپس روابط بین آلاینده هوا و برخی پارامترهای هواشناسی با استفاده از داده‌های میانگین روزانه آماری محاسبه شد. داده‌های باد (سرعت، جهت)، رطوبت نسبی، دما، ساعت آفتابی، تبخیر و بارندگی به عنوان متغیرهای مستقل در نظر گرفته شدند. میزان ارتباط بین غلظت آلاینده و پارامترهای هواشناسی با استفاده از معادلات رگرسیون خطی و غیر خطی برای شرایط سالانه و فصلی با استفاده از نرم افزار SPSS محاسبه شد. آزمون RMSE نشان داد که در میان مدل‌های مختلف برای پیش‌بینی در این تحقیق، مدل stepwise (گام به گام) بهترین مدل برای بررسی وضعیت آلاینده مونوکسیدکربن در شهر اهواز است.

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