# Descriptive-statistical Analysis of the Relationship between Atmospheric Conditions and Urban Pollution in Tabriz

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(Resaved 14 September 2018 – Accept 15 October 2018)

## Abstract

Air pollution is one of the environmental challenges of today's world in most major cities. Considering the importance of atmospheric conditions in the occurrence of air pollution, this study was conducted to investigate the relationship between urban pollution and atmospheric conditions of Tabriz. At first, 32 air pollution periods (125 days) were identified in Tabriz by studying changes in $PM_{10}$, CO and $SO_2$ during 2008-2013. In order to create the database, 12 effective climate variables were collected at the mentioned days, and their correlation with the changes in the concentration of pollutants were investigated through descriptive analysis, Pearson correlation statistics and stepwise regression. The descriptive analysis of the values of the sustainability indices showed that the KI index in 12% of the cases and the TTI index in the 17-day period was between relatively unstable and relatively stable range, and in the rest of the cases, there was complete stability. The horizontal visibility proved to be between 600 and 10000 m, while the air temperature was between 12.6 to 21.7 TºC, which fell down to below zero at 37 days. Surface pressure in 91% of days was more than 1015 hpa, and the maximum daily wind speed in 64% cases was less than 5 m/s. A quantitative analysis of the inversion layer characteristics indicated that its ΔT average with 4.89 TºC is in intensive category. The temperature inversion depth was 9 to 1769 m and their height was 454 m above the station, indicating the formation of inversions at low altitude in contaminated days. According to the Pearson correlation results, maximum wind speed and air pressure had the highest correlation with $PM_{10}$. Also, there was a significant correlation between $PM_{10}$ concentration and all three stability indices, and this contaminant produced the highest correlation coefficient with inversion intensity and top height of the inverted layer with 0.26 and 0.20, respectively. Carbon monoxide concentration had significant correlation with climatic parameters of

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the land surface except the wind. Meanwhile, the highest correlation was estimated between temperature and relative humidity with coefficients of 0.64 and -0.77, respectively. Although the concentration of $SO_2$ in the studied years never reached unhealthy conditions, its concentration changes showed the highest correlation with the temperature, maximum wind speed and sea level pressure.

**Introduction**

Air pollution is one of the problems most of the major cities, including Tabriz, face with. The large industries located in the west and southwest of Tabriz have been introduced as the most important causes of the pollution of Tabriz until the 80s. However, based on the results of the recent research, motor vehicles have been regarded as the most important source of air pollution in this city. Considering the effects of air pollution on water, soil, air, climate, living organisms, and also the human health, the study of the conditions creating and intensifying the air pollution was required. With a disadvantage in natural air conditioning and the atmospheric stability in the cold period of the year, the air of Tabriz always faces a temperature inversion, which often causes the air pollution in the city. Therefore, the present study was conducted to investigate the relationship between atmospheric parameters and air pollution in Tabriz.

**Materials and methods**

The statistical periods studied in this research are from 2008 to 2013 during the cold period of the year. In this study, three data types were used: a) daily and hourly meteorological variables such as horizontal visibility, relative humidity, temperature, pressure (mean sea level), mean and maximum wind speed; b) daily and hourly statistics of atmospheric pollutants including CO, $SO_2$, $PM_{10}$ and $PM_{2.5}$. The data is related to the mean data of the stations of the Namaz square (Raste Kooche), Rah Ahan, Hakim Nezami, Bagh Shomal and Abersan. Data recorded for the concentration of aerosols from 2008 to 2013 is related to particles less than 10 microns, but since 2013 onwards, the particle concentrations of less than 2.5 microns ($PM_{2.5}$) were recorded instead of 10-micron particles; c) the upper atmosphere observational data (from the radiosonde) including atmospheric stability indices (SI, KI, TTI), and information on the properties of temperature inversion layer (including temperature inversion intensity, reverse layer depth, and top height of temperature inversion layer were obtained from the Wyoming University website.

**Discussion and results**

Based on the data used, 32 air pollution incidents, which included 124 days, were identified. To form the database, 12 effective climate variables were

collected at the mentioned days and their relationship with the changes in the concentration of pollutants was investigated by descriptive analysis, Pearson correlation statistics and stepwise regression. The descriptive analysis of the values of the stability indices showed that the KI index in 12% of the cases and the TTI index in the 17% of days were between relatively unstable and relatively stable conditions, and for the rest of the days the complete stability was observed in the atmosphere. Horizontal visibility was at 600 to 10,000m and the temperature was between 12.6 and 21.7 $^0$C, which was below zero at 37% of days. The sea level pressure in 91% of days was more than 1015 hPa, and the maximum daily wind speed in 64% of days was less than 5 m/s. The analysis of the quantitative properties of temperature inversion layer shows that the temperature inversion with an average of 4.89 $^0$C indicates a relatively intense temperature inversion in the polluted days.

According to the results of Pearson correlation, the maximum parameters of wind speed, mean wind speed, and air pressure have the highest correlation with the changes in the concentration of $PM_{10}$ aerosols. There was a significant correlation between $PM_{10}$ concentration and all 3 stability indices. Also, among the properties of the temperature inversion layer, $PM_{10}$ concentration had the highest correlation coefficient of 0.26 with the temperature inversion intensity.

Other than with wind, the CO has a significant correlation with other climatic variables of the land surface. Meanwhile, it has the highest correlation with temperature and relative humidity variables with the coefficients of 0.44 and -0.57 respectively. Between the quantitative properties of the temperature inversion layer, the concentration of CO had the highest significant correlation coefficient at 95% confidence level with the temperature inversion intensity. During the studied years, the concentration of $SO_2$ was not close to unhealthy conditions, but the concentration of this pollutant in days with atmosphere stability and temperature inversion has increased and reached 53 ppb at the highest rate in study periods. $SO_2$ concentration has the highest correlation with daily pressure and temperature.

The result of stepwise regression for $PM_{10}$ pollutants revealed three maximum variables of wind speed, temperature inversion intensity, and KI index as the most effective determinant factors of $PM_{10}$ contamination. Among 12 independent variables, the final output of stepwise regression determined only the temperature and temperature inversion intensity as the most effective atmospheric parameters in changes in CO pollutant concentration. Also, the results obtained from the stepwise regression model for $SO_2$ proved that the average temperature, maximum wind speed and temperature inversion intensity had the highest effect on $SO_2$ process.

## Conclusion

Among the studied climatic variables, the maximum wind speed, temperature and air pressure are more correlated with pollutants. Among the sustainability indicators of atmosphere, the suspended particles showed the most significant correlation with the KI index and with SI and TTI in the next orders. Between the stability indices studied, CO showed a significant correlation with non-critical states of KI, and $SO_2$ pollutant showed a significant correlation with SI and KI indices. Results obtained indicated that the temperature inversion intensity has a positive correlation with all three pollutants, which manifests an increase in the amount of pollutants in intense temperature inversions. A reverse correlation of horizontal visibility with the concentration of $PM_{10}$ and $SO_2$ pollutants also indicates the effect of these pollutants on reducing the horizontal visibility. Also, the temperature was the most effective element in the process of pollutants of CO and $SO_2$. The wind speed has the highest correlation with aerosols. Of the studied variables, the temperature inversion intensity, the KI index (condition of atmospheric stability), and the rate of pressure affect the trend of increasing and decreasing the concentrations of all three pollutants.

**Keywords:** Urban pollution, atmospheric parameters, stability indices, Pearson correlation, Tabriz city.