

A study of the synoptic patterns with severe air pollution episodes in Tehran

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Intriduction

Air pollution in megacities is influenced by many factors such as topography, meteorology conditions, industrial growth, transportation systems, and increasing populations. Urban/industrial emissions from the developed world, and increasingly from the megacities of the developing world, change the chemical content of the downwind troposphere in a number of fundamental ways. Atmospheric pollution is becoming an increasingly critical problem to human health and welfare especially in megapolises. In fact, many factors affect air pollution and concentration of pollutants. Variations of meteorological conditions can play a vital role by influencing level of air pollutants. Variations in the physical and dynamic properties of the atmosphere on time scales from hours to days can play a major role in influencing levels of air pollutants. surface wind is very important for pollution dispersion and vertical thermal gradients can determine the extent which pollutants are diffused through the atmospheric column. A large number of studies have conducted on the relationship between air pollution concentrations and meteorological conditions (e.g., Alijani 2004; Adamopoulos et al. 1996; Makra et al. 2007; McGregor and Bamzelis 1995; Davis and Kalkstein 1990b). This article investigates large-scale weather conditions that have been a cause for severe air pollution episodes over Tehran area during the last decade (1999-2008).

Materials and methods

Air pollution episodes in urban areas follow certain pre-determined patterns, being associated with certain local meteorological conditions and emission of primary pollutants. In this article, the synoptic and local scale atmospheric circulation that prevails during air pollution episodes in a megacity-Tehran, is examined for a period of 10 years (1999-2008). This study investigates large-scale weather conditions that caused severe air

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pollution episodes over Tehran area during the last decade (1999-2008). Using 00UTC of Final analysis data set (FNL), daily meteorological parameters and Pollutant Standard Index (PSI) were investigated to relate synoptic characteristics of pressure patterns to high levels of air pollutants. The pollutants considered in this study were only in the gaseous form with SPI values of more than 200.

Results and discussion

Four episodes with high pollution concentrations ($PSI > 200$) were prevailing in the city in the period, and although they occurred in different seasons, but their pressure patterns have similar characteristics. High concentrations of air pollutants exist exclusively, during dominance of high pressure over Zagros chains and thermal low pressure over the Caspian Sea with an accompanied anticyclonic ridge in the midlevel atmosphere.

Results for the study period clearly show that anticyclonic conditions are associated with a higher frequency of severe air pollution episodes than synoptic conditions associated with cyclonic flow. This result confirms findings from other studies elsewhere, which have shown a close relationship between anticyclonic conditions and high pollution loads (McGregor and Bamzeli, 1995, Kalkstein and Corrigan, 1986; Davis and Gay, 1993). Often associated with anticyclonic conditions are weak winds, which limit ventilation and thus transport and dispersion of pollutants away from an area. Although the severe air pollution episodes have occurred in different seasons, but their pressure patterns have similar characteristics. The synoptic situations producing severe air pollution events are typically anticyclonic patterns dominant over Tehran area with a high frequency. Results for the study period have clearly shown that high concentration of air pollutants occurred exclusively during thermal high pressure periods over Zagros chain and south Alborz chain of mountains and thermal low pressure over the Caspian Sea accompanied with an anticyclone-ridge in mid level atmosphere. Although exploratory in nature, study results suggest that the synoptic method may offer considerable scope for evaluating air pollution potential. Sometimes the large-scale weather conditions are the dominant influences and at others the local conditions are prevalent, although normally both of them are always present. As a general rule one can state that during strong synoptic pattern, characterized by strong winds, clouds, and, at times, by precipitations, local influences are largely suppressed. However, when winds are weak and the sky is clear, the local effects mostly control the lowest layer of the atmosphere (Landsberg, 1980).

Conclusion

This is a significant result, while there has been a decrease in the pressure gradient over Tehran area and a thermal low and a thermal high pressure were dominant in the two sides of the Alborz Mountain, certainly it appears to indicate an air pollution potential in Tehran area. While these situations associated with a well developed ridge in the middle atmosphere, they are conducive to severe air pollutant built up in the atmospheric boundary layer due to suppression of vertical mixing heights and poor ventilation regimes. As on poor ventilation and vertical mixing days have the potential to build to considerable levels. The results show, in the severe pollution episodes of Tehran, the weak surface wind was observed over Tehran and west of the area. Boundary layer height limited to 50-200 meters above the surface. It is likely that such configuration of calm conditions and atmospheric stability account for high concentrations of pollutants. In conclusion, synoptic and mesoscale weather classification is a useful tool for studying the air pollutant concentration and dispersion in a megacity like Tehran.

Keywords: large-scale weather situations, severe air pollution, Pollutant Standard Index, Tehran

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