

Simulation of Tehran Air Pollution Dispersion Model in Windy Air Conditions

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Introduction

Population growth, along with the rapid development in industrial and many urban sectors, and lack of sustainable development approach in urban planning are all caused great changes in environment in form of pollution and ravage. In urban environments, complexity of spaces and urban manmade phenomena as well as the lack of regular and continuous measurement of atmospheric elements and components such as surface fluxes, turbulence intensity, overnight stable layer depth and inversion layer, daily mixed and boundary layer and energy balance components which are generally the input of dispersion models have made uncertain mechanisms in dispersion of pollutants over Tehran. One of the important aspects in the study of air pollution is how the pollutants disperse from sources of emissions. Wind direction, turbulence conditions and fluxes in near surface atmosphere are the most important climatic factors that affect dispersion pattern and distribution of air pollutants leaving from emission sources.

Study Area

Tehran having a population of about 8,300,000 and a 15 million-plus metropolitan area is Iran's largest city and urban area, and one of the largest cities in southwest Asia. Tehran (35° 42' N, 51° 25' E) covers an area of 750 km² and is situated in a semi-enclosed basin south of the Alborz Mountains. Its location for a big city is unusual, since it is not near a river or even close to the sea. The average annual rainfall is approximately 230 mm, with most precipitation falling in autumn and winter months. Due to high elevation (approximately 1140 m), aridity and latitude, the city experiences four seasons.

Climate can be extremely hot in summer (with mid-day temperatures ranging between 30 oC to 40 oC), and cold in winter when nighttime temperatures can fall below freezing point. Local precipitation is absent for six months of the year on the low-lying areas.

Tehran suffers from severe air pollution and the city often covers by smog making breathing difficult and causing widespread pulmonary illnesses. It is estimated that about 27 people die each day from pollution-related diseases. According to local officials, 3,600 people died in a single month due to the hazardous air quality. 80% of the city's air pollution is due to cars. The remaining 20% is due to industrial pollution. Other estimates suggest that motorcycles alone account for 30% of air and 50% of sound pollution in Tehran. Tehran is bound in the north by the massive Alborz mountain range that is stopping the flow of the humid Caspian wind. As a result, thermal inversion that traps Tehran's polluted air is frequently observed.

Material and Methods

The methodology is based on undertaking literature review to develop theoretical foundations and explanation of the research method. In this research, three-hourly wind velocity and wind direction

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data and air temperature of 2006 were obtained from Geophysics, Mehrabad and the Shemal-e-Tehran weather stations (Table 1). Also atmospheric gridded data obtained from NCEP/NCAR reanalysis dataset for surface and 700 hPa levels for prepared synoptic maps using GrADS software (Table 2). Mehrabad upper level atmospheric data has been taken from the University of Wyoming are used to identify effective thermodynamic indices on intensified or mitigation air pollution in Tehran. Moreover, two site emission data available in SO₂ of chimney exits south of Tehran including Tehran oil refinery source point and thermal power plant source point were used (Table 3).

In this research, using EDMF thermodynamic index available in The Air Pollution Model (TAPM), the dispersion pattern of pollutants in the air near the surface were studied under unstable weather and windy conditions over Tehran. Three-hourly meteorological data from three stations in Tehran were used to select two case studied. So two days with significant wind in all three weather stations were selected that they also include days of warm and cold periods. Then prevailing weather condition in synoptic-scale weather systems were evaluated by providing surface and upper level weather maps. Emission data from two point sources of Power plant and Tehran's oil refinery in south of Tehran used as the input to model. Atmospheric model with three nested cells with 4, 3.9, and 3 Km dimensions and pollution input with nets respectively 1000, 975, and 750 m were imported to model software. Pollution input is defined based on Eulerian and Lagrangian dispersion models, and their outputs were calculated for the innermost grid.

Results and Discussion

In September 27 and March 21, a low pressure is seen in the surface in southeast of Caspian Sea and a high pressure is located over northwestern Iran. Barometric trough with contours of 1008 to 1011 hPa of it is drawn to Tehran area. Wind vectors represent weak surface western wind over the area. At 4 AM local time, the values of the vertical velocity (Ω) are positive which represent the stable conditions; however, at 4 PM local time Ω becomes negative up to the level of 425 hPa and represents the unstable conditions (fig 3 and 4). Based on surface synoptic map in March 21, wind vectors represent high velocity and westerly direction. At 4 AM local time, vertical velocity is positive that indicates descending conditions, but in 4 PM it becomes negative and represents ascending condition (Fig 5 and 6).

The result of model output for both dates show different atmospheric conditions in different time scales. Analysis of the Probability Density Function (PDF) for the summer wind condition (September 27) show that in 66% of winds in this day show 2 and 3 m/s velocity, and more than 53% of winds blow from northwest. Figures 7 to 11 show that the instability and turbulence conditions intensify in daytime and reduce at night. Figures 12 and 13 show the differences of spatial dispersion of pollutants in the daily average with (a) Eulerian and Lagrangian dispersion models for summer under windy conditions.

Analysis of windy conditions in winter (March 21) by PDF is shown in figure (15). It shows westerly winds dominant and in this time more than 85% of winds velocity is more than 3 m/s. During winter condition, dispersion of pollutants in both Eulerian and Lagrangian models are the same in terms of density and wind direction of dispersions (fig 19).

Conclusion

Simulation results indicate that in windy conditions of warm period, in south of Tehran with dry and hot air and soil, turbulent kinetic energy increases due to wind velocity and unstable atmospheric conditions and horizontal transfer of pollutants is associated with upward movement. Conversely, in the cold period, wind causes to increase the cooling air, so it result to decrease of turbulent kinetic energy in the atmosphere, hence pollutants are mostly transport horizontally.

Key Words: Air pollution, thermodynamic indices, TAPM, EDMF, Tehran.