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ANALYZING AIR CANALS OVER GREATER TEHRAN AREA FOR DILUTION OF AIR POLLUTANTS

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ABSTRACT

Because of the massive global environmental impacts of fossil fuel use, decision makers seriously want to find ways to reduce air pollution in their own countries. Moreover environmental concerns are the driving force behind the development of clean and renewable energy sources. There are two basic methods to reduce air pollutants. First is emission reduction from fossil fuel energy sources and second is use of appropriate meteorological approaches for diluting air pollutants. In this paper, air canals over greater Tehran area are analyzed. Since this mega city is surrounded by mountains and is almost in the form of a big valley; air pollutants are trapped in boundary layer. Therefore wind could be of too much importance. In this regards relatively strong winds make urban atmosphere turbulent and pollutants are transported to the upper urban atmosphere. In this work, we firstly determine wind field and wind rose over greater Tehran area. In the next stage, air canals are specified too. At the end, we present some suggestions for strengthening these canals such as plantation of trees in appropriate locations, selection of suitable building's orientation against the wind and so on.

Key Words: Air pollutants, Deposition, Disperse, High and Low Pressure, Turbulence

1. INTRUDUCTION

The atmosphere has served as a sink for emissions of volcanoes and a variety of geographical processes, forest and grassland, and decomposition and other biological processes for hundreds of millions (if not billions) years. It has also served as a sink for pollutants generated by human activities, proceeding from man's first use of fire to the smelting of metal ores and use of fossil fuels such as coal, oil, and natural gas to motor vehicle and other emissions from our every industrialized and technologically advanced modern times (Arya, 1999).

Despite its vastness, the atmosphere (at least in the short term) is not perfect sink. Its ability to carry away (transport), dilute, (disperse), and ultimately remove (deposition) waste products released to it is limited by various atmospheric motion phenomena. Pollutant concentrations may reach unacceptable levels as a result of local or regional overloading of the near-surface atmosphere, topographical barriers, and micro-, meso-, and macroscale air motion phenomena. The atmosphere serves as a medium for atmospheric chemical reactions that ultimately serve to remove contaminants. These reactions may produce pollutants that may themselves pose significant environmental concerns. Levels of long-lived pollutants such as methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2) may increase, causing global warming and in the case of halogenated hydrocarbons, stratospheric ozone (O_3) depletion (Godish, 2004).

Because of technological and economic limitations, we have little choice but to use the atmosphere for the disposal of airborne wastes. Like other natural resources, our use of the atmosphere has to be a wise one, recognizing its limitations and using in a sustainable way.

2. WIND

Wind is a meteorological variable commonly used to describe air movement in the horizontal dimension. Wind result from difference in air pressure that are caused by unequal heating of the earth's surface. In the absence of friction and the earth's rotation, air would flow from areas of high to low pressure. The direction of airflow is controlled by a combination of the pressure gradient force, Coriolis Effect, and friction. Horizontal winds are characterized by both wind speed and direction. Wind speed is also affected by horizontal pressure and temperature gradients and friction, which is proportional to the roughness of earth's surfaces (surface roughness). For continuously emitting stack sources, dilution begins at the point of release. This plume dilution is inversely proportional to wind speed; i.e., by doubling wind speed, pollutants concentration is decreased by 50% of its initial value. The effect of wind speed is to increase the volume of air available for pollutant dispersal. Urban areas are characterized by relatively high surface roughness and, as a consequence, diminished wind speeds. This is ironic in the sense that urban areas, because of their relatively high pollutants emissions, are in greater, not lesser, need of being ventilated by wind. Directional aspects of global winds include the Prevailing northeasterly flows in the subtropics, southwesterly flows in the middle latitudes, and easterly flows at high latitudes in the northern hemisphere. They also include the cyclonic (clockwise) and anticyclonic flows associated with migrating low- and high-pressure systems. Because flows are somewhat circular, wind direction will depend on one's position in the circulating pressure cell. It also depends on local topography. At night in river valleys, airflows are downslope and downriver; they are upslope during daylight hours. Along sea and lake coasts, winds during clear weather flow inland during the day and waterward at night (Sorbjan, 2003).

Wind direction is quite variable, with large changes often occurring over relatively shorts periods of time. A change in wind direction of 30˚ or more in 1 h is not uncommon. Over a period of 24 h it may shift by 180˚. Seasonal factors may cause wind direction variations of up to 360˚. Wind direction and variability can have significant effects on air quality. Areas downwind of point sources where winds are relatively persistent may experience relatively high ground-level concentrations compared to other areas at similar distances. If the wind is more variable, pollutants will be dispersed in larger volume of air and be more equally distributed around the source; ground-level concentrations are therefore likely to be lower. Wind direction is particularly important in the transport and dispersion of pollutants over large geographical areas. For instance, it is southwesterly airflows that carry acid precursors from the U.S. Midwest to the northeastern states and southeastern Canada. Similar flows have transported pollutants from countries of southeastern Asia to the West Coast of U.S. [1]. Although global winds are important in determining the prevailing winds in a given area, local climatic conditions may have an influence on the most common wind directions. Local winds such as sea and land breeze are always superimposed upon the layer scale wind systems, i.e. the wind direction is influenced by the sum of global and local effects. When larger scale (synoptic patterns) winds are light, local winds may dominate the wind patterns. Mountain regions display many interesting weather patterns. One example is the valley wind which originates on south-facing slopes (north-facing in the southern hemisphere). When the slopes and the neighboring air are heated, the density of the air decreases, and the air ascends towards the top following the surface of the slope. At night the wind direction is reversed, and turns into a downslope wind. Figure 1 shows schematic diagram of mountain winds. These local winds may have important role on air quality, i.e. these may caused dilution of pollutants or concentrating of them [URI1].

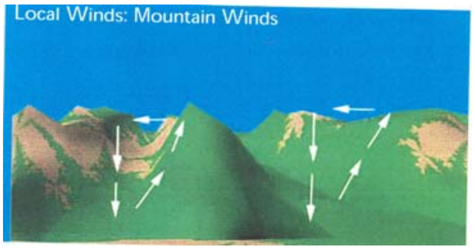

Figure 1. Mountain Winds.

3. DATA

In this study, we used 9 synoptic and climatological stations in Great Tehran and neighboring areas. Table 1 shows type and geographical specification of the stations under study.

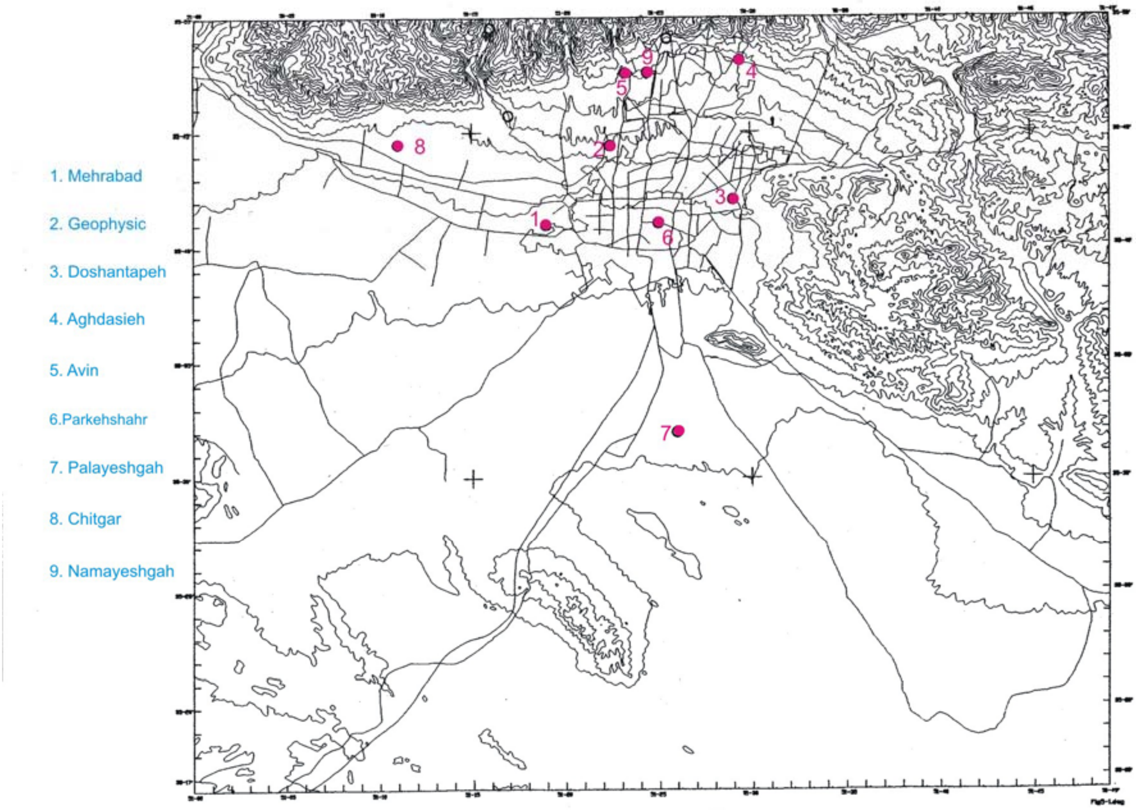

Figure 2.Topographical map of Tehran area and also location of studied meteorological stations.

Figure 2 shows studied stations network which superimposes upon topographical map of Tehran and its surroundings. Scale of map is 1/250000. Geographical area is limited to 51˚ to 51˚ 45′ of longitude and 35˚ to 35˚, 30′ of latitude. Interval in both axes of the map is 5 minutes (Research and…, 1995)

Table 1. Type and geographical characteristics of 9 meteorological stations.

	Name	Type	Latitude ˚ ′	Longitude ˚ ′	Height over mean sea level (m)
1	Mehrabad	Synoptic	35 , 41	51 , 19	1191
2	Geophysics	Synoptic	35 , 44.5	51 , 22.5	1260
3	Doshantapeh	Synoptic	35 , 42	51 , 29	1209
4	Aghdasieh	Synoptic	35 , 48	51 , 29	1548
5	Evin	Climatological	35 , 47.5	51 , 23.5	1520
6	Parkeshahr	Climatological	35 , 41	51 , 25	1210
7	Palayeshgah	Climatological	35 , 32	51 , 26	1160
8	Chitgar	Synoptic	35 , 42.5	51 , 13	1270
9	Namayeshgah	Climatological	35 , 47.5	51 , 24.5	1541

Source: IRIMO

3. TOPOGRAPHICAL CHARACTRISTICS OF TEHRAN

Tehran's **t**opographical structure plays a significant role on air pollution. This city is surrounded by mountains from northern and eastern sides. Because of the horseshoe shape of mountains around the Tehran, local winds can not transport pollutants far from the city; therefore pollutants move between north and south of area. In the same region, prevailing winds and synoptic patterns appoint final situation of air quality.

4. WIND ROSE

You will notice that strong winds usually come from a particular direction. To show information about the distributions of wind speeds, and the frequency of the varying wind directions, one may draw a so-called wind rose on the basis of meteorological observations from sufficiently long period. We have divided the compass into 8 sectors, one for each 45 degrees of the horizon. A wind rose may also be drawn for 12 or 16 sectors. For instance Figure 3 shows wind rose of Geophisics station for 5 years period (1991-1995. Width of the rectangle is directly related to the wind speed, by increasing wind speed, its width increases (scale of wind speed varies 1 to 37 knots). Length of rectangle indicates percentage of wind directions frequency, in other words, the longer length shows more percentage of wind directions frequency. Percentage of calm (wind speeds less than 0.5 meter per second) is showed in center of wind rose diagram. Mean wind speed is superimposed upon scale of wind speed percentage (uniform circles) as a closed curve. Figure 3 shows wind rose of months of April, May, and June and whole season of spring in the Geophysics station. It is clear that the prevailing wind directions are north and northeast with speeds in the range of 4 to 6 knots, and fastest winds have speeds in the range of 28-33 knots.

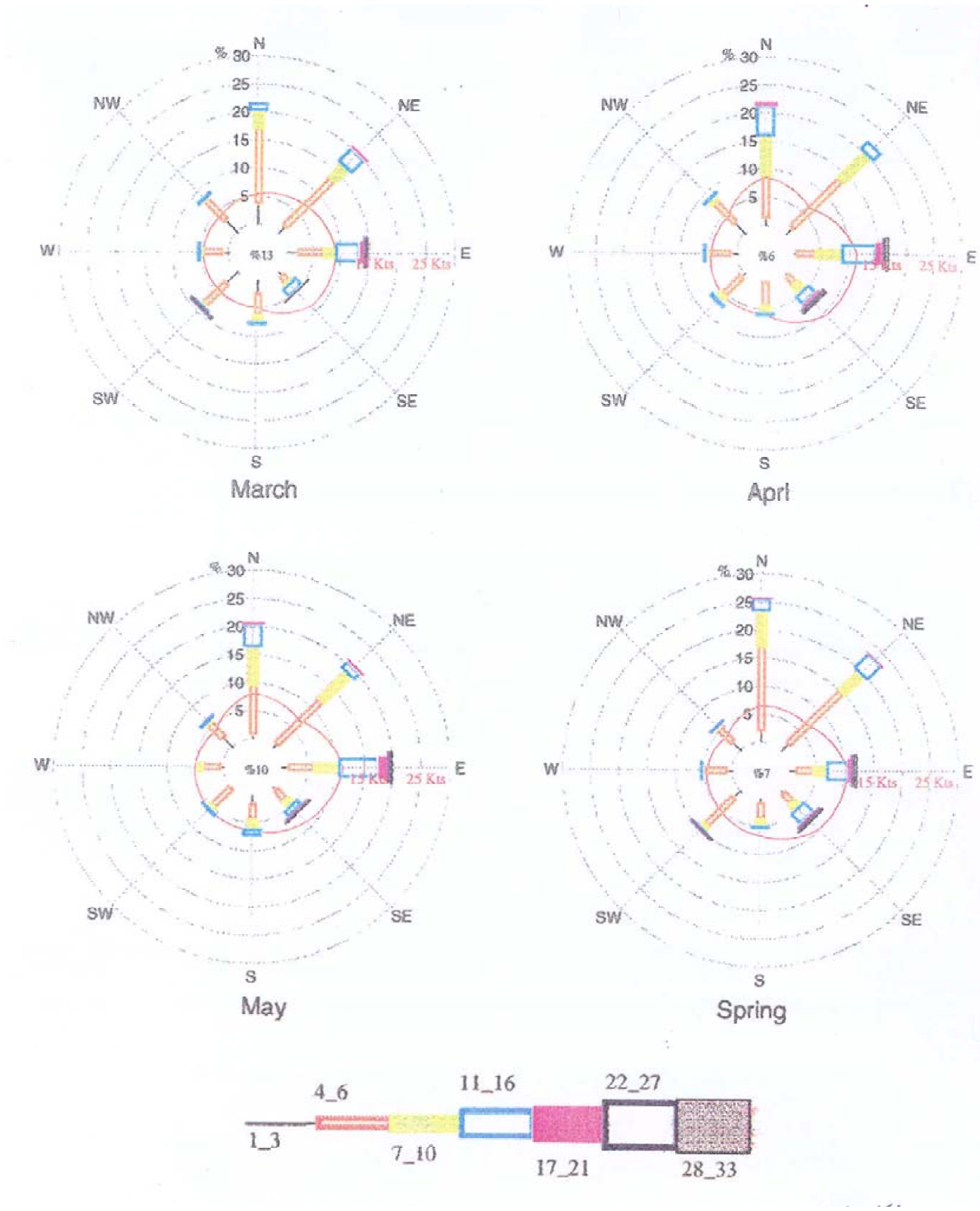

Figure 3. Wind rose of Geophysics station in 3 months and season of spring (1991-1995).

5. ANALYSIS of AIR CANALS OVER TEHRAN AREA

During spring, Prevailing winds enter metropolitan area of Tehran from west and northwest directions. Figure 4 shows the pattern for Greater Tehran Area on a topographic map. The red circles indicate studied stations over Great Tehran Area and the red arrows represent prevailing wind in the stations. The green and blue arrows respectively reveal wind vectors and streamliners over studied region.

In summer, prevailing winds are blown from southwest and divided to two branches. First have southern direction and the other passes southern and central parts of Tehran and then exits from eastern and southern edges of the city. Figure 5 illustrates whole situations for summer season.

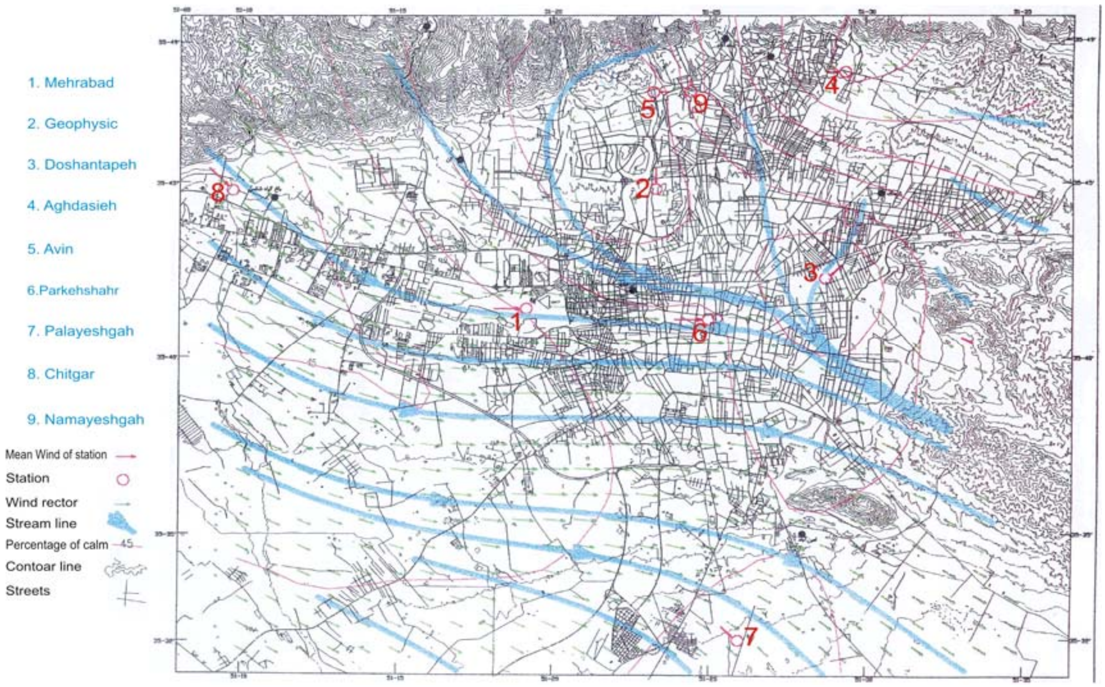

Figure 4. Air canals over Tehran in spring time for 1986 to 1995.

In autumn, winds are frequently western (Figure 6) and Winds mostly are blow from northwest to the southeast in winter season (Figure 7).

We superimposed 4 figures (4-7) relating to the 4 seasons and found that direction of prevailing winds is western whole of year. Figure 8 indicates this results and streamlines (dark blue tick lines) have western direction.

6. STRENGTHING OF AIR CANALS OVER TEHRAN

There are different methods for strengthen of air canals that here we briefly introduce some of them). One of them is movement industrial centers from west to the east of Tehran. The other method is creation of appropriate vegetation cover in the windward edge of the city, especially in the northwest parts of the city (Melaragno, 1980). Height and width of buildings, orientation of them against the wind, and orientation of the streets are known as control factors to air flows in urban internal parts of Tehran (Jenab, 1984). The existing of tall buildings cause air pollution to concentrate in downtown of the city. It is suggested that tall buildings are exposed to the prevailing wind by small side. In such cases, we would have better movement of air throughout city (Kasmaee, 1984).

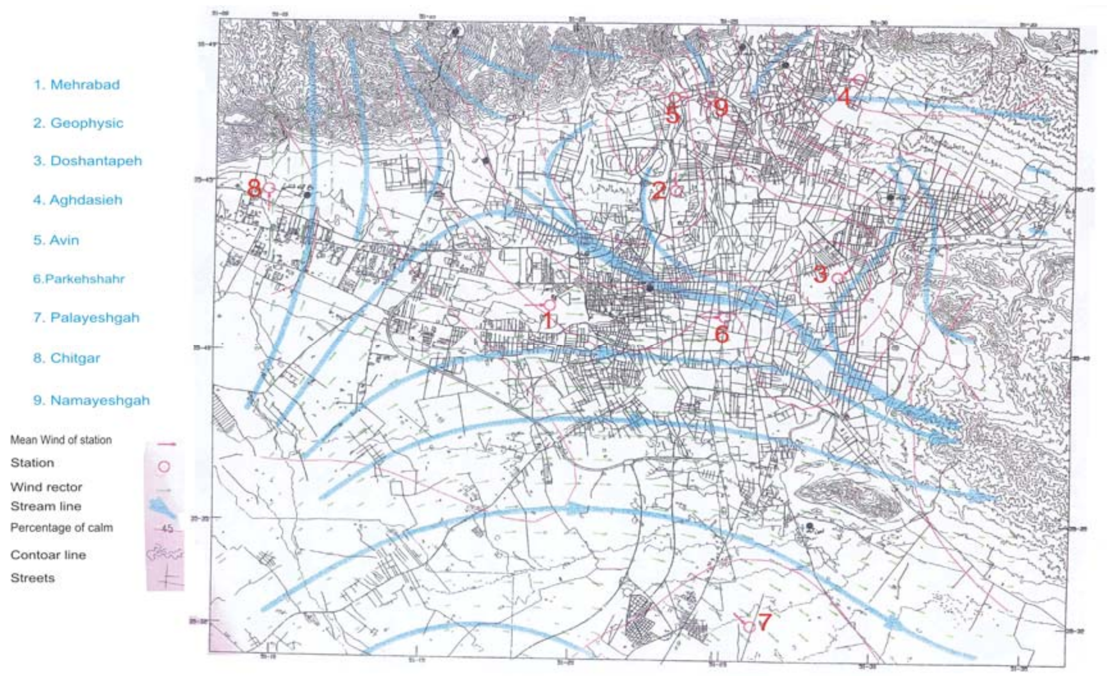

Figure 5. Air canals over Tehran in summer time for 1986 to 1995.

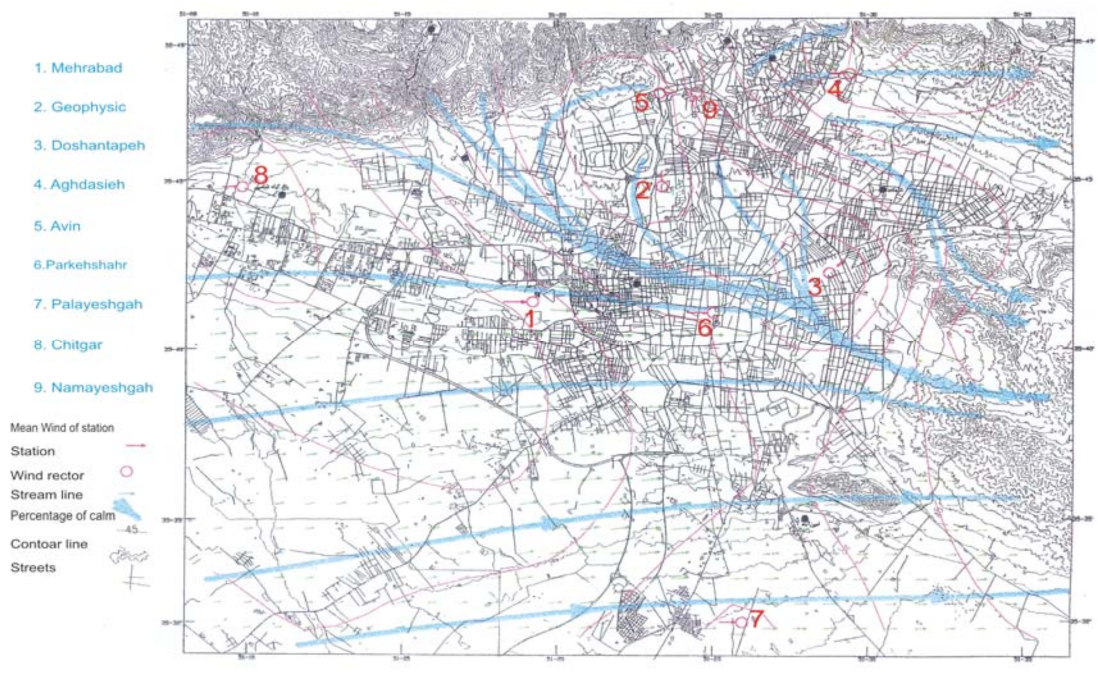

Figure 6. Air canals over Tehran in autumn time for 1986 to 1995.

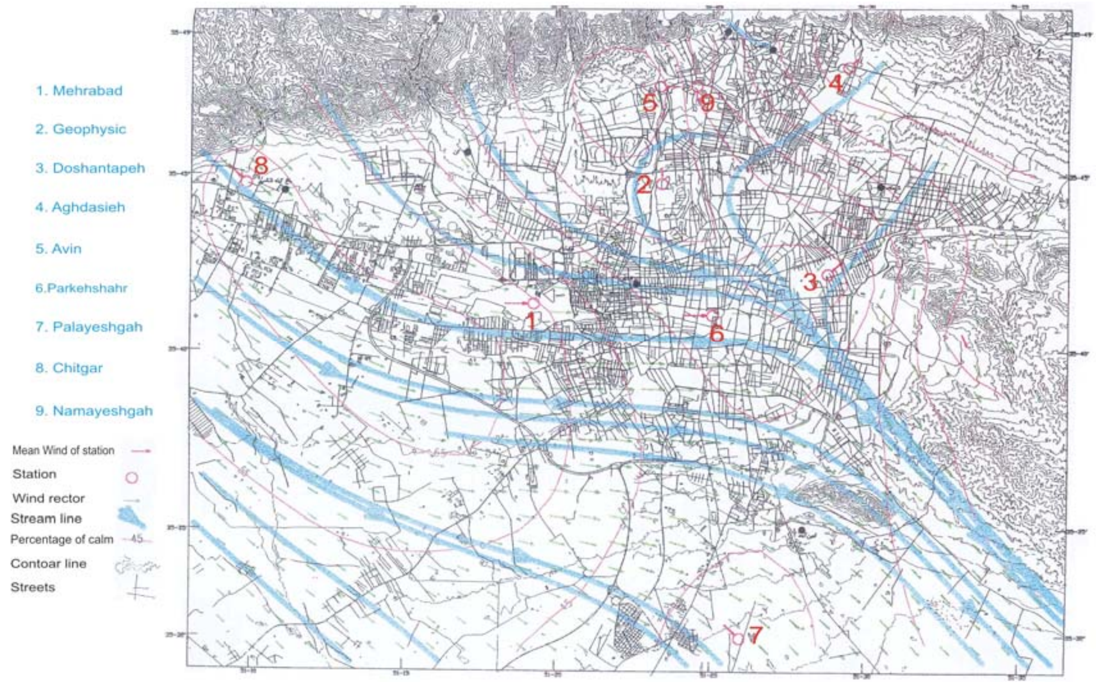

Figure 7. Air canals over Tehran in winter time for 1986 to 1995.

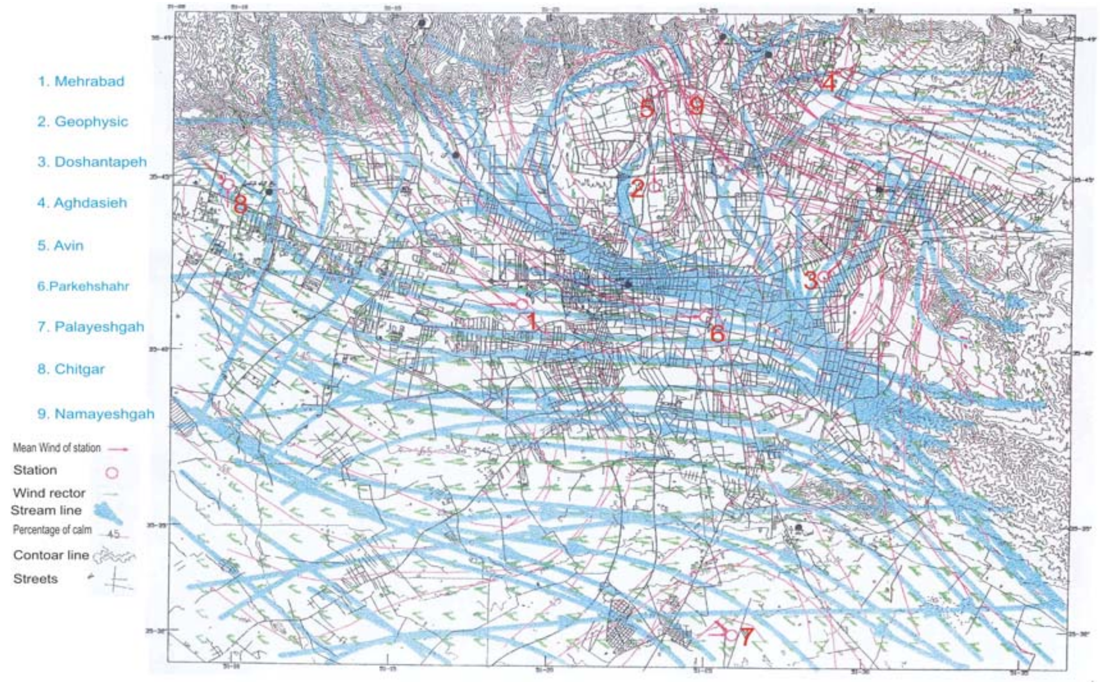

Figure 8. Annual air canals over Tehran for 1986 to 1995.

7. CONCLUSION

In this work, we understand that winds over Greater Tehran Area are very complicated from season to season and prevailing winds mainly are western. As Tehran has its specific complex topography and almost located in a valley, it is vulnerable to air pollution. Our obtained results show that we have to be very careful in establishment of factories and workshops (point sources) in the city. At the moment, most of pollution producing industries is located in the west of Tehran and pollutants are easily transported to the city and remain in there for considerable period of time (few hours to few days). These situations especially occur in the late autumn and early winter.

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