



## Tehran Air Quality Index During 2000-2009

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Tehran's air pollution has become a national environmental problem. The correct understanding of the pollution levels over an urban region is of great importance to both government authorities and services and to the community. This is particularly true for high polluted urban regions such as Tehran. It is important to recognize the levels of air quality by means of an easily understandable manner even for non-specialists. In this study an attempt is made of the application the quality index (AQI) in a network of 10 measuring stations, during the period of 2000-2009 to give better understanding in changes of air quality during this period and the effect of air pollution control policies on air quality index. Results showed decreasing air quality index values during 2000-2009. There is a sharp decrease in air quality index values during 2004-2006 that has a good correlation with development of railway in municipal transportation and decrease of automobile age by replacing old cars with new.

**Key Words:** Air quality index, Criteria pollutant, Tehran.

### INTRODUCTION

Air pollution represents a threat to both the environment and human health and it is estimated that millions of tons of toxic pollutants are released into the air each year<sup>1</sup>. On the other hand urban air pollution causes five times as many deaths and illnesses as malaria and is among the largest contributors to regional morbidity<sup>2</sup>.

The air quality index (AQI) is an index for reporting daily air quality. It tells us how clean or polluted the air is and what associated health effects might be a concern for us. The air quality index focuses on health effects we may experience within a few hours or days after breathing polluted air. The air quality index varies from 0 to 500. The higher the air quality index value, the greater the level of air pollution and the greater the danger to health is<sup>3</sup>.

Air quality index is a standardized number and colour-coded index. It helps people understand the quality of air each day and the associated health risks. Air quality announcements through media, including television, radio, newspapers, broadcast telephone messages and the internet, are designed to alert people that they should limit outdoor activities to avoid ambient air pollution when the air quality index is more than 100, especially children, the elderly people with cardiopulmonary diseases, such as asthma. States are required to report the air quality index daily to the general public for the metropolitan statistical areas (MSAs) with a population size larger than

350,000<sup>3</sup>. Air quality index is calculated based on eqn. 1 and Table-1. Also air quality index values and the level of health concerns are showed in Table-2.

$$I_P = \frac{I_{Hi} - I_{Lo}}{BP_{Hi} - BP_{Lo}}(C_P - BP_{Lo}) + I_{Lo} \quad (1)$$

where:  $I_P$  = the index for pollutant P;  $C_P$  = the rounded concentration of pollutant P;  $BP_{Hi}$  = the breakpoint that is greater than or equal to  $C_P$ ;  $BP_{Lo}$  = the breakpoint that is less than or equal to  $C_P$ ;  $I_{Hi}$  = the AQI value corresponding to  $BP_{Hi}$ ;  $I_{Lo}$  = the AQI value corresponding to  $BP_{Lo}$ .

About half of the world's population now lives in urban areas because of the opportunity for a better quality of life. The concentrations of people and their activity are exerting increasing stress on the natural environment, with impacts on urban, regional and global levels<sup>4</sup>.

Tehran is the biggest city and capital of Iran with population of about 8 million. It is located at longitude of 35° 36' to 35° 50' and latitude of 51° 17' to 51° 33'.

Cheraghi<sup>5</sup> reported that air quality has exceeded 329 days (90 % of cases) and 34 days (9.3 % of cases) above the standard level in Tehran and Isfahan, respectively, in 1999. This research also indicated that in both cities, most of criteria pollutant was carbon monoxide, 96 and 70 % in Tehran and Isfahan, respectively.

Ardakani<sup>6</sup> reported that air quality index values in 75 % of the cases exceeding the standard level set by U.S. environ-

TABLE-1  
BREAK POINTS FOR THE AIR QUALITY INDEX

Air quality index	PM <sub>10</sub> (µg/m <sup>3</sup> ) 24 h	CO (ppm) 8 h	NO <sub>2</sub> (ppm) 1 h	SO <sub>2</sub> (ppm) 24 h	O <sub>3</sub> (ppm) 1 h
0-50	0-54	0.0-4.4	-	0.000-0.034	-
51-100	55-154	4.5-9.4	-	0.035-0.144	-
101-150	155-254	9.5-12.4	-	0.145-0.224	0.125-0.164
151-200	255-354	12.5-15.4	-	0.225-0.304	0.165-0.204
201-300	355-424	15.5-30.4	0.65-1.24	0.305-0.604	0.205-0.404
301-500	425-604	30.5-50.4	1.25-2.04	0.605-1.004	0.405-0.604

mental protection agency (AQI = 100) and air quality was very unhealthy in 13.7 % of the cases and hazardous in 0.27 % of the cases in 2001. Also most of criteria pollutant were carbon monoxide with 84.6 % of the cases.

TABLE-2  
AIR QUALITY INDEX VALUES AND ASSOCIATED HEALTH CONCERNS

AQI values	Levels of health concern (air quality conditions)
0 to 50	Good
51 to 100	Moderate
101 to 150	Unhealthy for sensitive groups
151 to 200	Unhealthy
201 to 300	Very unhealthy
301 to 500	Hazardous

Ardakani *et al.*<sup>7</sup> also showed that air quality index was above the standard level in 262 days of year 2004, with cases of very unhealthy and hazardous at 12 % and 0.5 %, respectively. Also CO was criteria pollutant in this year.

Lin *et al.*<sup>8</sup> showed that during 2000, air quality index values were 3.6, 4.6, 10.4 and 0.27 per cent of cases above the standard level (AQI = 100) in north, central, southern and eastern Taiwan respectively.

Molina *et al.*<sup>4</sup> found that, while problems, resources and outlook of each city are different from other cities the holistic approach to solve environmental problems is the same. Although showed that there is no single strategy in reducing air pollution.

Kyrkilis *et al.*<sup>9</sup> analyzed hourly data of air pollutants from 4 monitoring stations, during 1983-1999 and revealed that Athenian population was exposed to high levels of pollution; a gradual increase of days with unhealthy conditions was detected for 1999.

Anttila and Tuovinen<sup>10</sup> found during the period of 1994-2007 that concentrations of SO<sub>2</sub>, CO and NO<sub>x</sub> declined considerably and widely across Finland and the reductions in NO<sub>x</sub> and CO concentrations were comparable to those in national road traffic emissions; they also revealed values for O<sub>3</sub> to have show large background change, that was increasing in the urban areas, with decreasing PM<sub>10</sub> because the major transported ions from long distances by the large-scale reduction in sulphur emissions, possibly played a significant part in the decreases in the mean PM<sub>10</sub> concentrations.

Kaushik *et al.*<sup>11</sup> collected data for total suspended particulate matter (TSPM), PM<sub>10</sub>, SO<sub>2</sub> and NO<sub>2</sub> in the 8 districts of Haryana, India, from January 1999 to September 2000 and showed that concentration of TSPM and PM<sub>10</sub> were above the standard level at almost all sites. The average ambient air

concentrations of SO<sub>2</sub> and NO<sub>2</sub> were below the permissible limits at all centers, while the air quality index in these districts for residential, sensitive and commercial areas corresponded to moderate to severe pollution which is a cause of concern for population in these cities.

Hamekoski and Koskentalo<sup>12</sup> present that SO<sub>2</sub> concentration decreased in the Helsinki metropolitan area in the past two decades and NO<sub>2</sub> levels has had no clear change, while there has been a decreasing trend in CO concentrations.

In this paper for the first time attempt has been made to quantify the trend in air pollution during 10 years (2000-2009), from measurements from 10 monitoring stations (Aghdasieh, Bazar, Fatemieh, Zheophizik, Shahre Rey, Poonak, Parke Roz, Golbarg, Masoudieh and Ostandary) in Tehran that analyzed and trends were compared among these stations.

## EXPERIMENTAL

Concentrations of CO, PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>2</sub> and O<sub>3</sub> during 2000-2009 were determined by Tehran Air Pollution Control Company at 10 monitoring stations. Table-3 and Fig. 1 show coordinates and locality of monitoring stations in Tehran, respectively. As it can be seen in Fig. 1, the network spatial coverage is good with stations being in central areas and suburb of Tehran.

TABLE-3  
TEHRAN AIR POLLUTION MONITORING SITES

Station Name	Longitude	Latitude
Aghdasieh	35° 48' 0.21"	51° 29' 6.11"
Bazar	35° 40' 38.06"	51° 25' 23.56"
Fatemieh	35° 43' 16.39"	51° 24' 28.47"
Zheophizik	35° 44' 48.24"	51° 23' 10.70"
Parke Roz	35° 44' 23.60"	51° 16' 4.39"
Shahre Rey	35° 36' 16.47"	51° 25' 32.08"
Golbarg	35° 43' 51.69"	51° 30' 22.07"
Masoudieh	35° 37' 48.10"	51° 29' 56.48"
Poonak	35° 45' 46.42"	51° 18' 51.61"
Ostandary	35° 43' 48.49"	51° 25' 35.20"

After collecting the data from these stations, missing data were excluded from the study and daily air quality index and criteria pollutant were computed by equation 1.

As some government policy such as development of railway in municipal transportation, decrease of automobile age by replacing old cars with new, increasing of automobile production and management of gasoline consumption and change of gasoline car to CNG car affected air quality in this period. In this regard we attempt to overlay this policies on air quality index index in order to clarify the trend of air quality index between 2000 and 2009. Data on number of wagons and automobile age obtained from official report.



Fig. 1. Map of Tehran showing air quality monitoring stations

## RESULTS AND DISCUSSION

### Tehran air quality during 2000 to 2009

**Aghdasiyeh station:** Aghdasiyeh station is one of the oldest stations amongst 10 stations. In this station, cases of good and moderate air quality index were 78.3 and 84.5 %, respectively in 2002 and 2003, while in these two years total percentages of unhealthy and hazardous situations were 4.2 and 0.7 % respectively. On the other hand total percentages of unhealthy and hazardous situations were 2.7 and 7.1 % for 2001 and 2008 respectively.

Also at this station highest criteria pollutants were  $\text{NO}_2$  with 33.1 %,  $\text{PM}_{10}$  with 77 %,  $\text{CO}$  with 33.3 %,  $\text{PM}_{10}$  with 65.3 %,  $\text{NO}_2$  with 33.1 %,  $\text{O}_3$  with 45.7 % and  $\text{O}_3$  with 61.2 %, for 2000, 2001, 2002, 2003, 2007, 2008 and 2009, respectively.

**Bazar station:** Bazar station has only 3 years data. Results of data analysis show that total percentages of cases of good and moderate were 78.8 % in 2000, while total percentage of cases of with very unhealthy and hazardous situations was 21.1 % for 2002. Also at this station criteria pollutants were  $\text{CO}$  with 78.2 %,  $\text{CO}$  with 59.1 % and  $\text{PM}_{10}$  with 60.1 %, for years 2000, 2001 and 2002 respectively.

**Fatemiyyeh station:** The Fatemiyyeh station was established in 2000 but it has recorded data only 6 years. Results show that total percentages of cases of good and moderate were 84.8 and 88.2 % in 2007 and 2008, respectively, while values of unhealthy and hazardous situations were 56.5, 37.9 and 25.5 % for 2000, 2001 and 2003, respectively. Overall average cases of very unhealthy and hazardous situation were 29.5 and 2.7 % respectively, during the period of 10 years.

Also results show that in this station  $\text{CO}$  was the only criteria pollutant with 94.4, 93.7, 90.7, 87.3 and 61.1 % for 2000, 2001, 2002, 2004 and 2007 respectively.

**Zheophizik station:** The Zheophizik station with 3 years data gathering was analyzed and results showed that cases of good and moderate situation had increase from 2006 to 2008, cases of good and moderate situation was 87.8 % at 2008, 2006 had the worst quality, the cases above the standard level ( $\text{AQI} = 100$ ) were 28.2 % at 2006, while that this cases was 12.2 % for 2008.

The results also show that during this period at this station criteria pollutants were  $\text{CO}$  with 80.8 % and 47.9 % and  $\text{O}_3$  with 29.3 %, in 2006, 2007 and 2008 respectively.

**Parke Roz station:** In this station exist 2 years data. 2008 had better air quality than 2009, since total percentage of cases of good and moderate were 96.1 and 91.1 % respectively, on the other side total percentage of cases of very unhealthy and hazardous situation was 1.8 % in 2008. Also at this station highest percentage of criteria pollutant was  $\text{PM}_{10}$  with 50.6 % and 58.9 % for two year 2008 and 2009, respectively.

**Shahre Rey station:** This station has 4 years data. The results show that 2009 had the best air quality, because total percentage of cases of good and moderate was 91.7 %, while 2006 had the worst air quality, because the total percentage of cases of unhealthy, very unhealthy and hazardous was 15.3 %.

Also at this station highest percentage of criteria pollutants were  $\text{SO}_2$  with 35.5 %,  $\text{PM}_{10}$  with 47.8 %,  $\text{CO}$  with 28.4 % and  $\text{PM}_{10}$  with 52.1 %, for years 2006, 2007, 2008 and 2009, respectively.

**Golbarg station:** Results of 2 years data of this station show that 2009 had the better air quality than 2008, because percentage of cases below the standard level ( $\text{AQI} = 100$ ) were 76.7 and 65.4 % in 2009 and 2008 respectively, on the other hand total percentage of cases of unhealthy, very unhealthy and hazardous was 20.3 % for year 2008. Also at this station highest percentage of criteria pollutant was  $\text{PM}_{10}$  with 46.2 % and 40 % for 2008 and 2009 respectively.

**Masoudeyhe station:** This is the one of the new established stations, that has only 2 years monitoring data. The results show that 2009 had better air quality than 2008, because cases of below standard level was 81.9 % in 2009 comparing to 33.3 % in 2008. Also at this station only criteria pollutant was  $\text{O}_3$  with 56.9 % and 76.6 % for 2008 and 2009, respectively.

**Poonak station:** According to 3 years data in this station, 2009 had the best air quality, because cases of above standard level ( $\text{AQI} = 100$ ) were 16 % in 2009; 2007 had the worst air quality with 32.6 % of cases above the standard level. Also at this station criteria pollutants were  $\text{SO}_2$  with 44 %,  $\text{SO}_2$  with 32.5 % and  $\text{PM}_{10}$  with 49.6 %, for 2007, 2008 and 2009, respectively.

**Ostandary station:** Ostandary station has only 1 year data. In 2009 65.2 % of days were unhealthy for sensitive groups and  $\text{CO}$  was the criteria pollutant.

**Air quality index values in Tehran during 2000-2009:** Fig. 2 shows the trend of air quality index in Tehran from 2000 to 2009; as shown in this figure, there is a downward trend from 2000 to 2003 (a) an upward trend from 2003 to 2004 (b), downward trend from 2004 to 2009 (c), after 2007 reach a steady state is reached (d).

On the other hand, as shown in Figs. 3 and 4, during this period air pollution control strategies such as: Development of railway in municipal transportation (Fig. 3) and decrease of automobile age by replacing old cars with new (Fig. 4), have positive effect on air quality index during this period.

**Tehran criteria pollutant during 2000-2009:** As Tehran criteria pollutant data during 2000-2009 shown, in Aghdasiyeh, Parke Roz and Golbarg stations  $\text{PM}_{10}$  is the most criteria pollutant, while  $\text{CO}$  is the most criteria pollutant in Bazar, Fatemiyyeh, zheophizik, Shahre Rey and Ostandary stations on the other hand in Masoudieh and Poonak stations Ozone and  $\text{SO}_2$  are the most criteria pollutant respectively in this period.

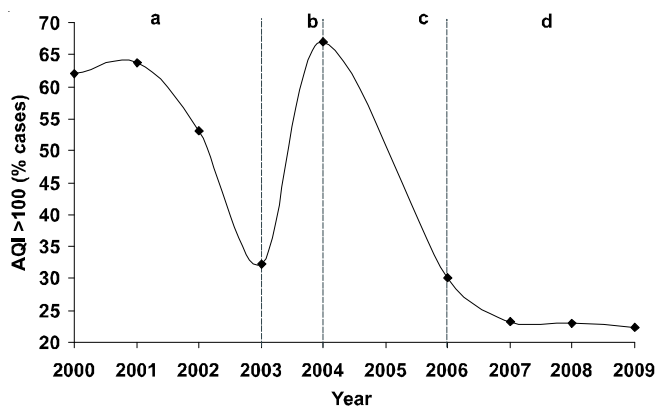


Fig. 2. Frequency of cases having AQI above the standard level (AQI = 100) in Tehran during 2000-2009

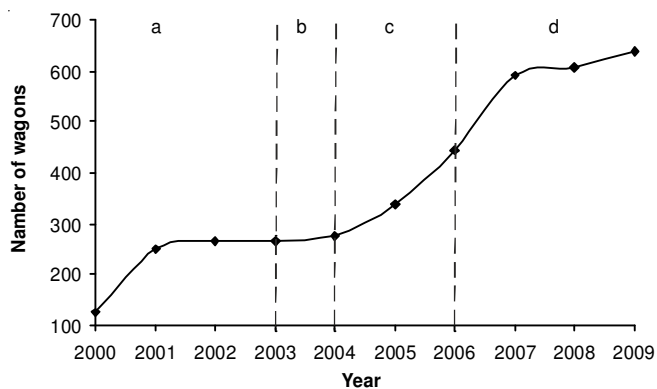


Fig. 3. Number of wagons in Tehran during 2000-2009

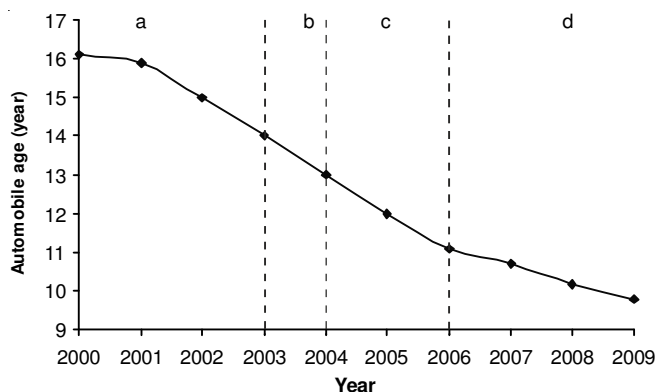


Fig. 4. Automobile age in Tehran during 2000-2009

## Conclusion

Based on this study, it can be easily concluded that for combating air pollution, different approaches must be taken and in this regard different roles must be established. For approaching these goals also an organization must be monitored the air quality for assessing the effects of policies and make a good decision based on monitoring the trend.

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