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The trend of air quality index (AQI) in Tehran during (2011-2016)

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ABSTRACT:

Introduction: Tehran city with the most population, about 4 million cars, million liters of fuels consumption, the presence of polluting industries such as petrochemicals and refineries, thermal power plants, and surrounding industrial towns is considered as one of the most populous and most polluted cities in the world . This study aims to investigate the trend of variation in air quality index in Tehran.

Materials and methods: In this descriptive and evaluative study, the air quality data of 7 monitoring stations in 2012 were taken from the Tehran Department of Environment and Tehran Air Quality Control Company(AQCC). The calculation of AQI was done according to the EPA guidelines.

Results: According to the results of this study, highest AQI averaging for 2016 (208.49±42.13) and the lowest for 2011 (134.13±46.80). Also observed that during the study period $PM_{2.5}$ particles with an average of 71.59% is the most important factor in increasing the air quality index.

Conclusion: It was observed that in the cold seasons of the year, due to the temperature inversion phenomenon in Tehran and the increase in the concentration of pollutants, air quality in most regions of Tehran is in unhealthy conditions, but in other season of the year the air quality is in moderate condition. Among the index pollutants, particulates are the major cause of Tehran's air quality decline.

Introduction

Today, due to the heterogeneity and diversity of air pollutants, the EPA uses indicators to express daily air quality reporting, in addition to setting a separate standard range for each pollutant1[1]. These indicators alert the public to the quality of the air in terms of clean or contaminated air[2]. The most common indicator is the air quality index, which calculates for five major air pollutants including particulate matter, nitrogen dioxide, sulfur dioxide, carbon monoxide and ozone[2, 3]. Who reports that particles smaller than micron and SO_2 can cause respiratory and cardiovascular diseases, such as asthma, bronchitis, heart attacks, lung function interference, and mortality [4]. In some European cities, there has also been

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a six percent increase in mortality, with a concentration of 10 μg/m^3 for particles smaller than 10 μm[5].

In recent years, the major health concerns of cities and changes in the distribution and NO of secondary pollutants such as ozone have been the size of particulate air. Epidemiological studies over the past two decades show that outdoor air pollution leads to increased respiratory failure, cardiovascular disease, chronic bronchitis, and even mortality, which is linked to global mortality, according to statistics[6-8]. With air pollution in 2000, 1.1 million to nearly one million, and in 2010 nearly 1.3 reported that more than 50% of this deaths were from the Asian continent.

In Iran, the process of industrialization and the increase in the number of vehicles has reduced the quality of urban air[9, 10]. According to similar studies , index values in Iranian major cities such as Tehran, Isfahan, Arak, Mashhad AQI and Tabriz were higher than the standard permissible values of the Iranian Environmental Agency for more than 80 days[8]. Also, the main cause of contamination of these cities was particles smaller than 10 μm. A study in Urmia showed that 25 days of the year was above the standard level and AQI had the main particulate matter index as the pollutant responsible.

Research in some major cities around the world, such as Beijing, China, Delhi, India, and some cities in Malaysia in 1997, showed that air was polluted more than 80% of the year, and most days, pollutants responsible for less than 10 μm were emitted. These cities were identified in terms of industry establishment. Vehicle and population traffic is similar to the metropolis of Iran, and most of the air pollution is caused by industries and urban traffic[11].

Tehran city with 8,693,702 populations, about 4 million cars, million liters of fuels consumption, the presence of polluting industries such as petrochemicals and refineries, thermal power plants, and surrounding industrial towns is considered as one of the most populous and most polluted cities in the world. In recent years, Tehran has faced serious air pollution problems, especially in the winter, due to the development of industries and the increase in the number of vehicles in urban areas. In addition, air pollution in Tehran is mainly influenced by the temperature inversion in the cold season and the Middle East dust storm in the warm season (from Iraq). This study aims to investigate the trend of variation in air quality index in Tehran, determine the most polluted and cleanest regions and determine the pollutants responsible for air quality reduction.

Materials and methods

This study was a descriptive and evaluative study of Tehran's air quality index. The air quality data of 38 monitoring stations in 2011-2016 were taken from the Tehran Department of Environment and Tehran Air Quality Control Company (AQCC). The position of the monitoring stations and the study area is shown in Fig. 2.

To calculate the air quality index, the pollutants information, such as, PM10, SO2, NO2, CO and O3 were collected from the Tehran Department of Environment and Tehran Air Quality Control Company (AQCC). The AQI calculation was carried out in two stages: first, according to the ambient air standard, the maximum amounts of 1-h ozone, maximum 1-h NO_2, maximum amounts of 8- h ozone and maximum 24-h and maximum hours for PM10 and SO2 were extracted. In the second stage, the AQI was calculated as per the

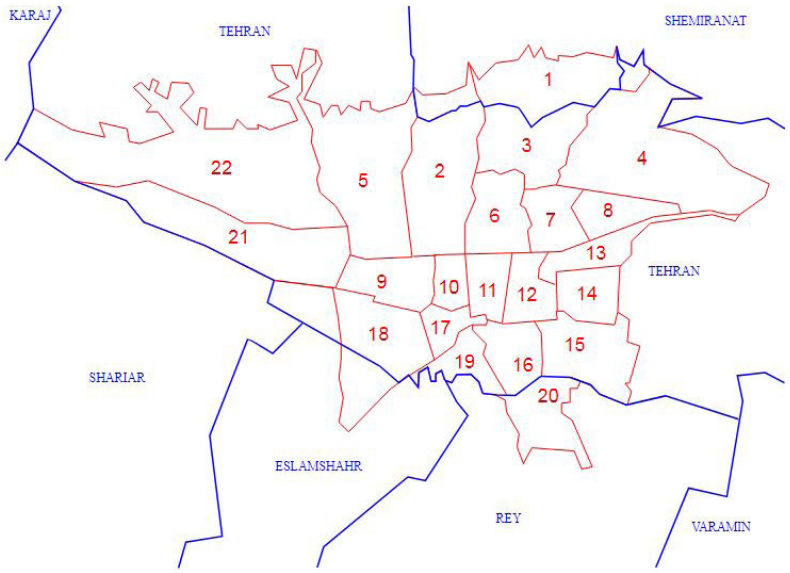

Fig. 1. Location of study

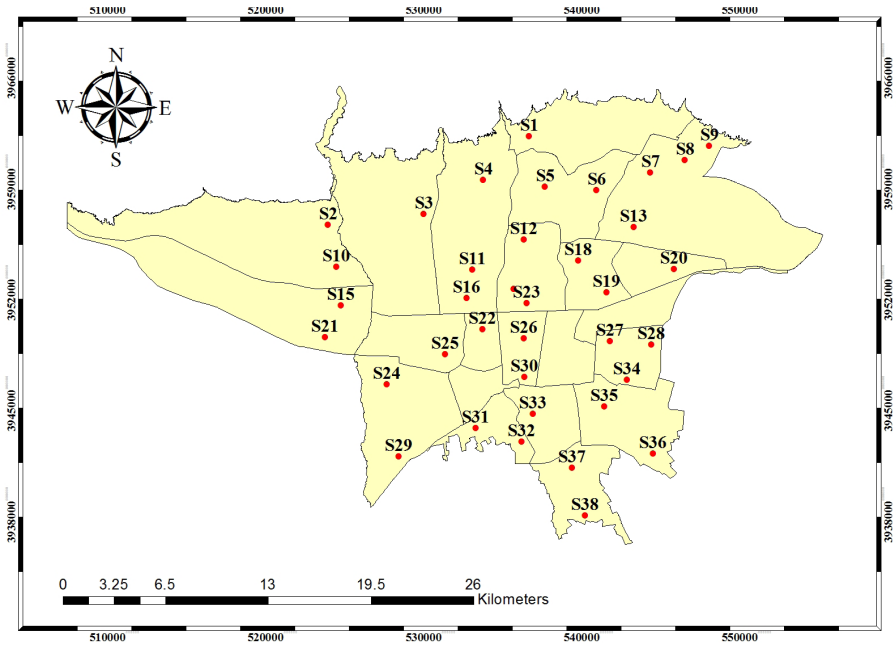

Fig. 2. Air pollutant monitoring stations in Tehran city

EPA guidelines, according to Eq. 1 by use of Excel. For accreditation, some of the AQI results were compared with the results of the EPA online application.

$$I_P = \frac{I_{HI} - I_{LO}}{BP_{HI} - BP_{LO}} \times (C_P - BP_{LO}) + I_{LO} \quad (1)$$

$$AQI = \max(I_{CO}, I_{NO2}, I_{SO2}, I_{O3}, I_{PM2.5}, I_{PM10}) \quad (2)$$

Where;

Ip = the index for pollutant p , Cp = the rounded concentration of pollutant p ,BPHI = the breakpoint that is greater than or equal to Cp ,BPLo = the breakpoint that is less than or equal to C IHI = the AQI value corresponding to BPHI ,ILo = the AQI value corresponding to BPLo

Table 1. AQI Break point

Air quality categories	AQI	Break point					
		NO_2 (PPM)	SO_2 (PPM)	CO (PPM)	O_3 (PPM)	$PM_{2.5}$	PM_{10}
Good	0-50	0-0.053	0-0.034	0-4.4	0-0.054	0-12	0-54
Moderate	51-100	0.054-0.1	0.035-0.144	4.5-9.4	0.055-0.07	13-35.4	54-154
Unhealthy for sensitive group	101-150	0.101-0.360	0.145-0.224	9.5-12.4	0.071-0.085	35.5-55.4	155-254
Unhealthy	151-200	0.361-0.64	0.225-0.304	12.5-15.4	0.086-0.105	55.5-150.4	255-354
Very unhealthy	201-300	0.65-1.24	0.305-0.604	15.5-30.4	0.106-0.2	150.5-250.4	355-424
Hazardous	301-400 401-500	1.25-1.64 1.65-2.04	0.605-0.804 0.805-1.004	30.5-40.4 40.5-50.4	0.201-0.6	250.5-350.4 350.5-500.4	425-504 505-604

Results and discussion

Table 2 shows the statistical summary of the air quality index in Tehran over the period 2011-2016, with the highest AQI averaging for 2016 (208.49±42.13) and the lowest for 2011 (134.13±46.80). According to the results of this study, the trend of changes in air quality index during the study period is increasing. This could be due to the increase in the number of monitoring stations during the study period as well as population growth, which was followed by an increase in the number of vehicles that resulted in an increase in pollutants and air quality index. Also in this study, it was concluded that the highest air quality index is related to cold seasons, which is due to the presence of invertebrates in cold seasons and higher number of pollutants than the cold seasons.

Table 3 shows the number of days each pollutant was responsible for the increase in air quality index as a percentage, It is observed that during the study period $PM_{2.5}$ particles with an average of 71.59% is the most important factor in increasing the air quality index. Among the studied years, $PM_{2.5}$ was responsible for 97.29% of pollutant days in 2013 and had the highest contribution to the increase in the index. It was air quality And had the lowest share in 2011 with 39.17 . Subsequently, O_3 and PM_{10}, had the highest (6.89 and 9.45) contaminants responsible for increasing the quality index, respectively.

Table 2. Descriptive statistics for AQI in Tehran's air in 2011 – 2016

Year	Average±SD	Max	Min
2011	134.13±46.80	383.1	65.7
2012	152.72±32.11	398.4	91.8
2013	166.59±30.49	286.1	25
2014	150.65±29.11	285.7	85
2015	196.68±48.46	496	68
2016	208.49±42.13	692.4	57.2

Table 3. Pollutants responsible for 2011-2016

year	Responsible pollutant (%)					
	PM_{10}	$PM_{2.5}$	NO_2	SO_2	O_3	CO
2011	18.08	39.17	17.26	0.57	22.46	2.46
2012	11.35	73.13	2.51	0	11.35	1.66
2013	0	97.29	0.54	0.27	1.36	0.54
2014	2.19	91.23	3.85	0	0.54	2.19
2015	14.24	70.41	6.57	0	1.66	7.12
2016	10.86	58.33	9.21	2.41	3.98	15.21
Average	9.45	71.59	6.66	0.54	6.89	4.86

Fig. 3 shows the status of the air quality index in the year in terms of degree of health risk. In 2011, most of the days were in unhealthy conditions for the sensitive groups and the AQI was between 101-150, in this year healthy days (0-50) Not present but days with unhealthy and dangerous conditions are significant.

Also in 2012 and 2015, the number of days that are unhealthy for the sensitive groups (150-101) and unhealthy (151-200) is approximately equal. But in 2013, 2014 and 2016 most of the days of the year are in unhealthy conditions (151-200), as can be seen throughout the study period very unhealthy and dangerous conditions have always existed. As mentioned, usually in the cold seasons of the year in Tehran the air quality index is placed in unhealthy and dangerous conditions. Due to the geographical conditions of Tehran, high volume of traffic, activities of industries located on the outskirts of the city.

In general, since the highest reporting quality among monitoring stations is usually reported as the city's air quality index, so in areas 10, 11, 13, 15, 18 and 21 as the most polluted regions except stations Which leads to an increase in the average daily air quality index.

The results of this study, along with similar studies by Globaz et al in the cities of Tehran and Isfahan, reported the origin of pollutants responsible for air quality index (O_3, PM, CO) in automobiles and industries. According to reports in Tehran , the annual average nitrogen dioxide is three times

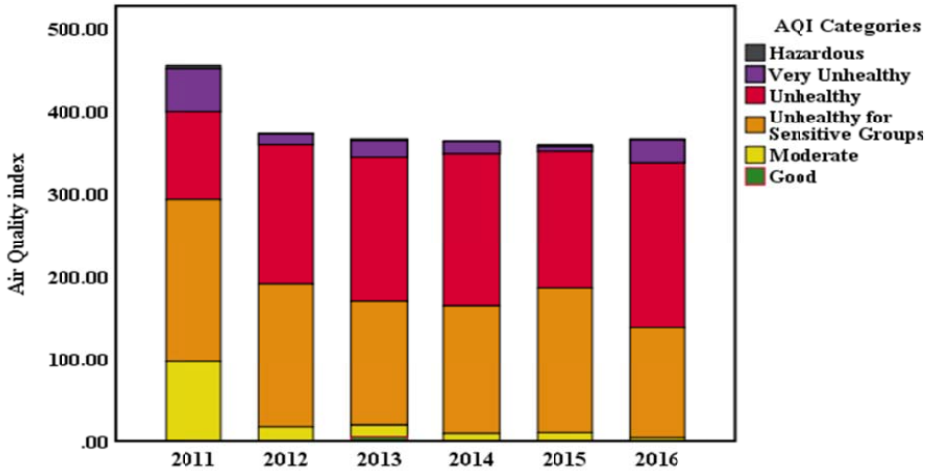

Fig. 3. Comparison of air quality index in the studied years (20112016)

the standard of Iranian fresh air and the average 8-h ozone was 27 times higher than the Iranian standard.

Conclusion

In general, if you want to describe Tehran's air quality, the high traffic areas in Tehran are mostly unhealthy on most days of the year. In fact, the main cause of Tehran's air pollution is the high number of vehicles. According to the latest statistics, there are about 4 million cars in Tehran, Moreover, given the political position of Tehran as the largest city in Iran, the existence of numerous industries, refineries, petrochemicals can have a significant impact on the air quality index. It was also observed that in the cold seasons of the year, due to the temperature inversion phenomenon in Tehran and the increase in the concentration of pollutants, air quality in most regions of Tehran is in unhealthy conditions, But in other season of the year the air quality is in moderate condition. Among the index pollutants, particulates are the major cause of Tehran's air quality decline. Among the particles, $PM_{2.5}$ particles have the highest concentration in the air of Tehran, which is the most important in terms of health effects.

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Competing interests

The authors declare no competing interests.

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Ethical considerations

This research is in accordance with reality and is based on scientific criteria.

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