Original Article

Investigation of Air Quality Index and PM_{10} and $PM_{2.5}$ in Arak

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Abstract

Background and purpose: In this study, the air quality index and concentration of particles such as PM_{10} and $PM_{2.5}$ were investigated in Arak.

Materials and Methods: To determine the concentration of PM_{10} and $PM_{2.5}$, 60 samples were collected by laser TSI model 8520 in summer and winter 2012. The collection site was around Arak city center.

Results: during the sampling period, as a matter of PM_{10}, the cleanest and the most polluted month were December and June with the average of 34.33 µg m^{-3} and 100.1 µg m^{-3}, respectively. The concentration of $PM_{2.5}$ was 12.93 and 53.17 µg m^{-3} for December and June, respectively. Meanwhile, in terms of air quality index (AQI), in 98.3% and 70% of cases, the concentrations of PM_{10} and $PM_{2.5}$, respectively were less than normal (AQI<100).

Conclusion: The concentration of PM_{10} in the study period was less than Environmental Protection Agency (EPA) 2006 guideline. Meanwhile, the concentrations of $PM_{2.5}$ in 30% of air samples were greater than EPA guideline. The average $PM_{2.5}/PM_{10}$ ratio during the sampling period was 0.41 compared to range 0.15 to 0.25 reported by EPA.

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1. Introduction

Particles (PM) are known as PM_{10} (particles with diameter equal to or less than 10 µg m^{-3} entitled as respirable particles), and PM25 (particles with diameter equal to or less than 2.5 µg m^{-3}). WHO has announced that over 2 million people in the word lose their life due to respiration of particles (1). Prolonged contact with respirable particles is likely to increase lung cancer and cardiac failure (2). Exposure to particle-induced pollution can be concomitant with spontaneous reactions such as palpitation, reduction of heart flexibility and increase of cardiac arhyithmias. There are some cases of sudden heart stroke risk in exposure to particles (3). In a study, it was shown that traffic- related pollution can jeopardize respiratory health and increase allergy which are common in urban areas of high pollution(4). Particles can contain dangerous and toxic compounds such as fluoride, lead, nickel, zinc, iron and copper (5,6). One of the major actions in this regard is to determine the real amount of aerosol pollutants and air quality index (AQI) compared with standard condition and inform people on due time. AQI, the promoted version of index of air pollution (PSI) is a uniformly developed system by US Environmental Protection Agency (USEPA) which delivers daily information about air quality to people. In the year 2000, USEPA updated PSI and renamed it AQI, which explains the effects of different levels of air pollution on public health and precautions actions during the increase of air pollution to unsafe level. Arak with the population of 511000 is located in the center of Iran as the capital of Markazi province, 288 Km far from Tehran. The area of Arak is 7178 Km^2, covering 24.4% of total area of the province. The summer is relatively warm and dry, but, the winter is cold and humid. The presence of factories and different industries in Arak and great transportation of vehicles cause the pollutants to be increased in the air. This research aimed to determine the concentration of PM_{10} and $PM_{2.5}$ and AQI in 2012.

2. Materials and Methods

To determine the concentration of PM10 and PM2.5, 60 samples were collected in summer and winter, 2012. The priority is to the region with the greatest probability of pollution. Therefore, the city center of Arak was chosen due to congestion and crowd. The interval of sampling was chosen to be each 3 days (at least 10 samples each month) as issued by EPA (5). It is worth mentioning the level of sampling was at 2m above ground level. Particle sampling was carried out by dust Track aerosol monitor (model 8520, TSI Inc). The instrument was programmed to record every 1 min. Dust Trak monitors were factory-calibrated for the respirable fraction of standard ISO 12103-1, A1 test dust (Arizona Test Dust), which is representative for a wide variety of particles and has a resolution of 0.001 mg m-3. It has been shown that Dust Trak does not provide really precise measurements but presents very high correlations when compared to gravimetric samplers (7). This system can store the values in its memory automatically and calculate minimum, mean and maximum particle concentrations. The numbers registered were analyzed by device software and excel 2007. Finally, to determine the air quality index (AQI), AQI calculator was used.

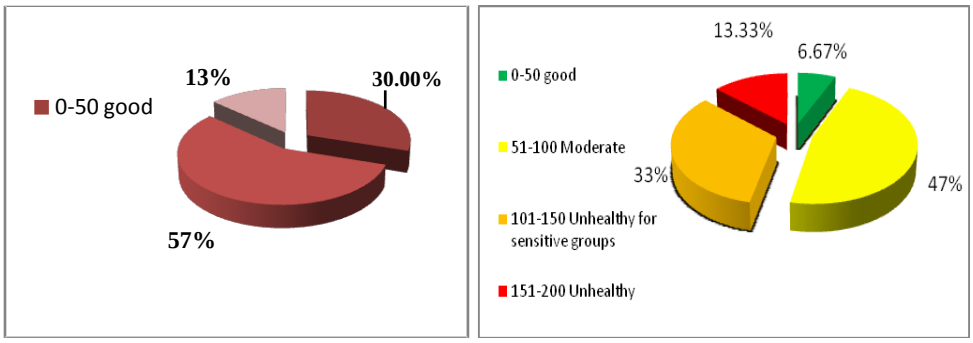
3. Results

According to table1, for $PM_{10,}$ December was the cleanest and June was the most polluted months, with 34.33 µg m^{-3} and 100.1µg m^{-3}, respectively. During the sampling period, with regard to $PM_{2.5}$, December was the cleanest and June was the most polluted months, with 12.93 and 53.17 µg m^{-3}, respectively. The mean of the 24hr concentration of PM_{10}, was 84.6 µg m^{-3}, with 96.98 and 61.3 µg m^{-3} in summer and winter, respectively. Also, during sampling period, the mean of 24-hr concentration for $PM_{2.5}$ was 31.46 µg m^{-3}.The concentration of $PM_{2.5}$ in summer and winter were 45.31 and 20.3 µg m^{-3}, respectively. Based on Figure 1, in terms of $PM_{2.5}$, AQI in summer was less than standard limit (AQI<100) in 53.34% of cases of which 12.5% and 87.49% were in good and moderate quality. In addition, in 46.66% of cases, the concentration of $PM_{2.5}$ was higher than standard limit (AQI>100), of which 71.4% and 28.6% of cases were in unhealthy for sensitive groups and unhealthy quality. In winter, in 86.7% of cases, the concentration of $PM_{2.5}$ was less than standard limit (AQI<100), of which 34.6% and 65.4% were in good and moderate level of air quality.AQI was less than standard limit (AQI<100) in 96.7% of cases in summer, in terms of PM_{10} , of which 3.5% and 96.5% were in good and moderate quality and in 3.3% of cases (Figure 2). Wherease, the concentration of PM_{10} was higher than standard limit (AQI>100), of which 100% was in unhealthy for sensitive groups level of air quality. In winter, in 100% of cases, the PM_{10} amount was less than standard limit (AQI<100), of which 50% was in good and 50% was in moderate. In Figure 3, correlation of $PM_{2.5}$ and PM_{10} concentration in 2012 is shown. In summer, the variations of 24h simultaneous PM_{10} and $PM_{2.5}$ concentrations were correlated with R= 0.79, and in winter, the variations of 24 h simultaneous PM_{10} and $PM_{2.5}$ concentrations were correlated with R= 0.98. This finding showed the strong correlation between PM_{10} and $PM_{2.5}$ concentrations.

Table 1. Mean and standard deviation of PM_{10} and $PM_{2.5}$ during different months sampling

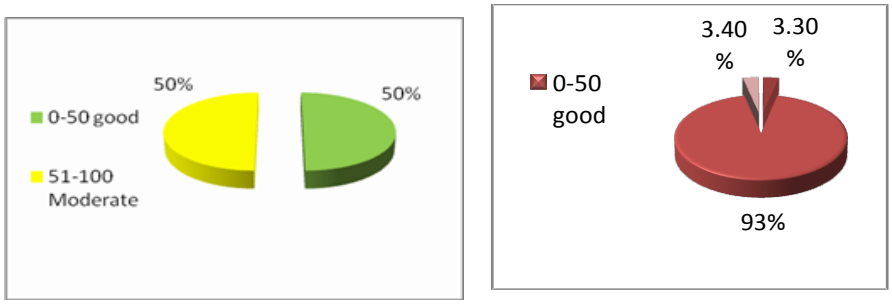
Months	Number of sample	Mean±SD (µgm^{-3})		Max (µgm-3)		Min (µgm-3)		$PM_{2.5}$/ PM_{10}
		PM_{10}	$PM_{2.5}$	PM10	PM2.5	PM10	PM2.5	
June	10	100.1±7.82	53.17±18.5	160	85	92	31	0.51
July	10	96.8±26.86	37.22±19.5	150	83.8	75	10	0.38
August	10	94.03±30.02	45.55±22.6	142	95.4	46.1	10.6	0.46
December	10	34.33±16.94	11.97±12.93	63	18.1	17.1	9.3	0.42
January	10	64.35±51.14	12.6320.94±	150	45	19.2	9	0.37
February	10	83.3±39.82	11.0426.99±	154	55	43	18.3	0.33

*SD:standard Deviation, PM: Particle Matter



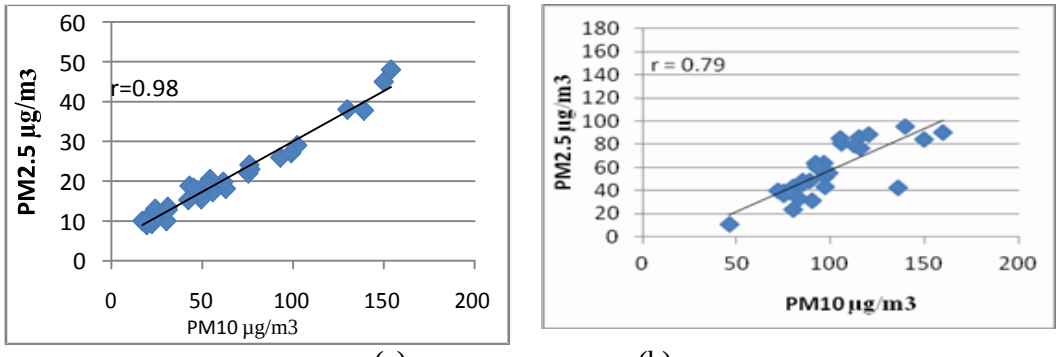
(a) (b)

Fig1. AQI levels for $PM_{2.5}$ concentration in winter (a) and summer (b)



(c) (d)

Fig2. AQI levels for PM_{10} concentration in winter (c) and summer (d)



(a) (b)

Fig 3. Correlation of $PM_{2.5}$ and PM_{10} concentration in summer (a) and winter (b)

4. Discussion

Particulate matter concentrations: Regarding the standard of EPA in 2006 which announced the maximum concentration of 24-hr for PM_{10} as 150 µg m^{-3}, the values obtained for the period of six months were less than the standard limit, but compared with WHO strategy in 2005 which announced the maximum concentration of 24-hr for PM_{10} as 50 µg m^{-3}, the values were greater than the strategy values in 83.3% of the cases. Based on standard EPA in 2006 which considered the maximum concentration of 24hr for $PM_{2.5}$ as 35 µg m^{-3}, in 30% of cases the results were greater than standard, but based on WHO strategy which announced the maximum concentration of 24-hr for $PM_{2.5}$ as 25 µg m^{-3}, in 55% of cases, the results were greater than WHO values. In similar studies, the great amount of aerosol particles has been confirmed in other cities of Iran (8-14). In a study in India, it was shown that presence of dust and great traffic affected the amount of particles by 42.6% and 3.36% (15). In Srilanka, the average of $PM_{2.5}$ concentration varied from 18 to 83 µg m^{-3} in outdoor(16). In a study in 6 municipal zones of Chile, the amounts of particles were greater in the central regions of the cities (17).

AQI levels: In 13.3% of cases, the concentration of $PM_{2.5}$ was higher than standard limit (AQI>100), of which 100% was in unhealthy for sensitive groups level of air quality. Totally, during sampling period, in terms of AQI, in 70% of cases, $PM_{2.5}$ and in 98.3% of cases, PM_{10} were less than standard limit.

Relationship between the PM concentrations: The season ratio of PM2.5/PM10 had little variability from 0.33 (February) to 0.51 (June). It indicates that coarse particles (greater than 2.5 microns) make up the majority of aerosol (Table 1). In similar studies by USEPA, the annual mean $PM_{2.5}/PM_{10}$ ratios measured in urban and semi-rural us areas were between 0.3 and 0.7(18). In a study, the average $PM_{2.5}/PM_{10}$ ratio for the five area in Tehran were 0.19(10). The average $PM_{2.5}/PM_{10}$ ratio during the sampling period was 0.41 compared to the range 0.15 to 0.25, reported by EPA(10). The results of this study showed that the amount of particles is greater in summer than in winter. The reason can be high relative humidity and precipitation in winter in Arak. It can be said that the concentration of particles was greater than EPA standard and WHO strategy in some days.

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