Journal of Air Pollution and Health (Spring 2018); 3(2): 109-118

Original Article

Available online at http://japh.tums.ac.ir

THE EFFECT OF NATIONAL EVENTS AND HOLIDAYS ON AMBIENT $PM_{2.5}$ CONCENTRATIONS

Ramin Nabizadeh Nodehi[1], Seyed Yaser Hashemi[1], Faramarz Azimi[1*]

[1] Department of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

ARTICLE INFORMATION

Article Chronology:

Received 25 April 2018
Revised 21 May 2018
Accepted 17 June 2018
Published 29 June 2018

Keywords:

Norooz; $PM_{2.5}$; holidays; Tehran

CORRESPONDING AUTHOR:

fazimi_lums@yahoo.com
Tel: (+98 21) 88954911
Fax: (+98 21) 88954911

ABSTRACT:

Introduction: The aim of this study was to evaluate the effect of national events and holidays on $PM_{2.5}$ concentrations in Tehran megacity.
Materials and methods: Air quality data were collected from Tehran Air Quality Control Company (TAQCC) over a period of four years, 2012 – 2015, then data from 10 air quality monitoring stations were processed using R- 3.3.3. The Iranian New year, Ashura and Eid al - Fitr were the national events that considered to study. To compare the daily mean $PM_{2.5}$ concentrations in Norooz holidays and other days of spring, the Mann - Whitney test and difference in $PM_{2.5}$ concentrations in each season were investigated with Kruskal-Wallis test.
Results: In Norooz holidays, the daily mean $PM_{2.5}$ concentrations in comparison with other spring days were decreased significantly ($P_{value} < 0.001$). The same decreasing occurred for 10 first days of Muharram too ($P_{value} < 0.01$) but the daily $PM_{2.5}$ concentrations during Ramadan days were significantly higher than that of summer days ($P_{value} < 0.001$). Based on Kruskal-Wallis test the difference in $PM_{2.5}$ concentrations between seasons was significant and only between summer-autumn ($P_{value} > 0.05$) and winter-summer ($P_{value} > 0.05$) was not.
Conclusions: The effect of holidays on $PM_{2.5}$ concentration was not observed in summer, however it was an effect in autumn. In addition the concentration of $PM_{2.5}$ was not influenced by holidays in winter regarding the thermal inversion and stability of air.

INTRODUCTION

Air pollutants may be in the form of solids, liquids and gases which are produced naturally and by man - made activities [1, 2]. Human activities and sources can release air pollutants through motor vehicles traffic, industry, power plants, transportation and domestic fossil fuels [3]. Currently, in most countries, air pollution caused by transportation is the most important environmental concerns [4]. However, a few efforts have been done

Please cite this article as: Nabizadeh Nodehi R, Hashemi S.Y, Azimi F. The effect of national events and holidays on ambient $PM_{2.5}$ concentrations. Journal of Air Pollution and Health. 2018; 3(2): 109-118

to specify the contribution of different sources in air pollution by studies in some cities. Particulate matters as one of the main air pollutants, are mostly emitted by transportation and vehicles, causing economic and health - related problems. Particulate matters can result many health risks in some areas without natural ventilation regarding the topography of district.

Tehran is a high - altitude city with the approximately population close to 8 million people and a land area of about 2,300 km^2. People are facing to large amount of air pollutants, especially particulate matter less than 2.5 μm. This city is surs rounded by mountains with an elevation of about 1000 - 3800 m located in north - south and east which exacerbate air pollution. [3, 5-8]. In addition, it has been proved that many customs and traditions can have impact on urban air pollution so that culture plays an important role in emission of air pollutants in urban air quality. Many studies have focused on influence of people participation in the traditions resulting increase of air pollution. For example, in a study conducted in east of China during the harvesting, a direct relationship between burning residual of crops and increasing the concentration $PM_{2.5}$ was observed [9-13]. Seasonal characteristics can cause severe changes in concentration of air pollutants, therefore, it should be considered and managed by administrators and authorities. Due to changes in concentration of pollutants, identifying behavioral patterns of pollutants in different seasons can help the management of pollutants concentration. These changes can vary from one year to the next year, associated mostly with changes in weather conditions [14]. Several studies have found that concentration of air pollutants in holidays are less than the other days. This reduction usually appears over the weekends [15-21]. The aim of this study was to evaluate the effect of national events (Norooz holidays), Ramadan moon and Ashora days on concentration of $PM_{2.5}$ in Tehran. Therefore forecasting the concentration of pollutants can be possible and helps to which decision should be made in high polluted days of next years.

MATERIALS AND METHODS

In case of gathering and processing of air quality data, Real-time hourly concentrations of $PM_{2.5}$ were obtained from 21 air quality monitoring stations (AQMSs) in Tehran during 2012 – 2015; all AQMSs were belonged to Tehran Air Quality Control Company (TAQCC). The air pollutant data measured at AQMSs are publicly available in Internet. At each AQMSs, $PM_{2.5}$ are measured using the beta - attenuation method. Daily average concentrations were calculated by the hourly data when more than 75 % of the data per day were valid measurements. Hourly concentration of pollutant was calculated for each air pollutant by averaging all available data of the selected monitoring stations. This cross sectional study was conducted by gathering data from Tehran Air Quality Control Company (TAQCC). Data of 2012 to 2015 were obtained and analyzed by R-3.3.3. In the current study, events such as Norooz (New Year holidays), 10 first days of Muharram and Ramadan were considered which have effects on the quality of life significantly. The seasonal concentration of $PM_{2.5}$ and the effect of traditional holidays on its concentration have been shown by figures.

The Mann-Whitney test was used to compare the mean $PM_{2.5}$ concentration in each event with the other days. Difference in $PM_{2.5}$ concentration in each season was investigated with Kruskal - Wallis test. Eventually, ultimate effect of holidays (one day, two days or more than two days) on the concentration of $PM_{2.5}$ has been examined.

RESULTS AND DISCUSSION

Norooz (Iranian new year holidays)

The Iranian new year or spring festival is one of the most important holiday for the Iranian people. The Festival generally begins at first day of spring and end of the 13th day. During Norooz holidays, government departments, schools and universities are closed. Therefore, most of people living inTehran travel to the other cities of the country. In most days of the year, there is a heavy traffic in Tehran, but it is not observed in Norooz holidays. The effect of new year holidays on $PM_{2.5}$ concentration in Tehran is shown in Fig. 1.

Regarding the daily changes in $PM_{2.5}$ concentration during the study period (2012 - 2015), it can be concluded that the $PM_{2.5}$ concentration in the mentioned holidays decreases to its lowest amount compared to the other days of a year.

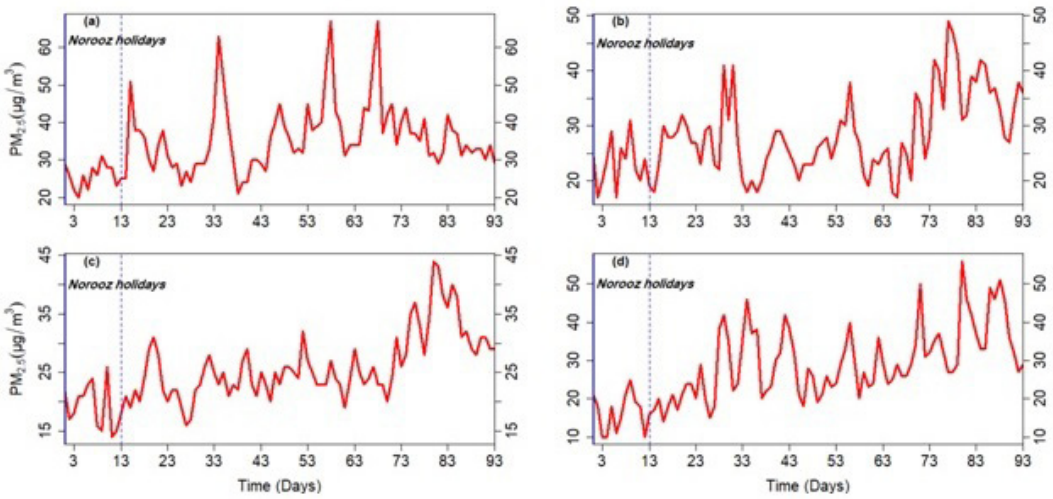

Fig. 1. Spring $PM_{2.5}$ changes in Tehran, in years 2012(a), 2013 (b), 2014 (c) and 2015 (d)

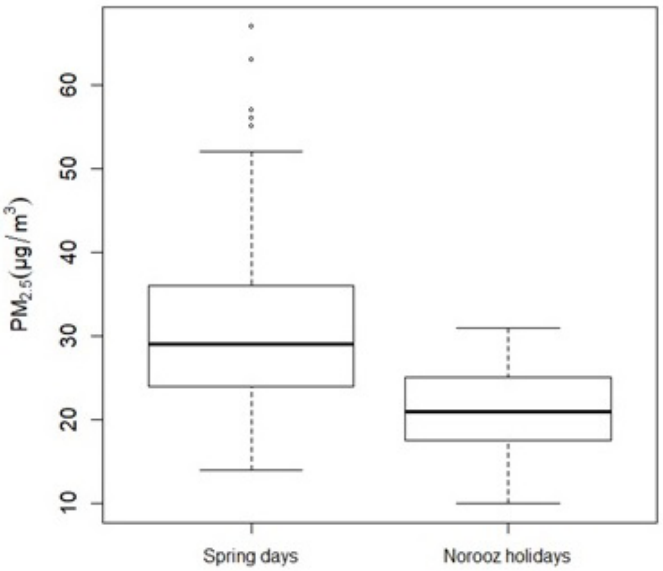

Fig. 2. Box plot of $PM_{2.5}$ concentrations of Tehran in Norooz compared to spring days

A box plot was used to compare the effect of Norooz holidays on $PM_{2.5}$ concentration. As shown in Fig. 2, the mean concentration during Norooz is lower than the other days of spring which represents the holidays effect on reducing the concentration of these particles. To show the effects of this holiday on $PM_{2.5}$ concentration the Mann-Whitney test was applied in order to compare the mean of two groups (Norooz holidays and other days of spring) for $PM_{2.5}$ concentration. Based on the Mann-Whitney test analysis, the $PM_{2.5}$ concentrations ($P_{value} < 0.001$) varied significantly in Norooz holidays (20.88 µg / m^3) compared to the other days of spring (30.31 µg / m^3).

Ramadan

Ramadan is one of the Islamic holy months in a year. It varies from 29 to 30 days. Fasting during Ramadan is an obligation during daylight and it has been mentioned in the Quran [22]. It is a religious event in Iran. Ramadan days effect on people activities and reduce unnecessary actions. Fig. 3 shows the effect of Ramadan on concentration of $PM_{2.5}$ in Tehran during the study years. Studying the changes in Ramadan shows that in the last days which coincides with the Eid al - Fitr, $PM_{2.5}$ concentration reduced, However, dust storms occurred in summer increased the concentration of $PM_{2.5}$ in some days.

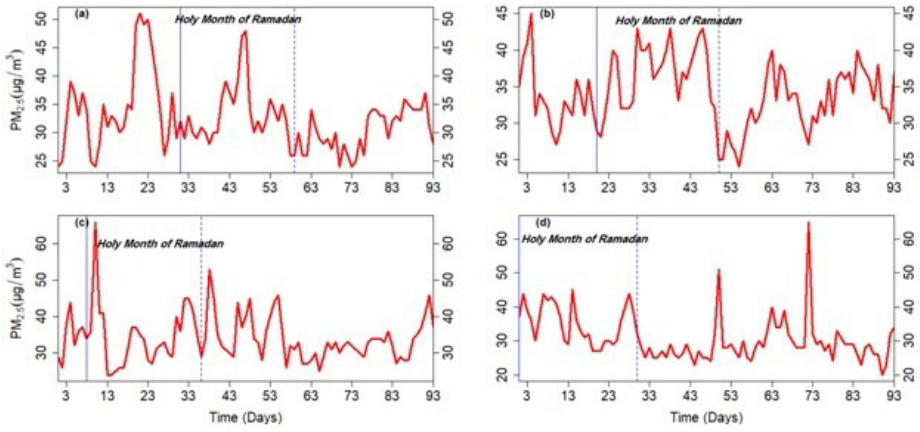

Fig. 3. Summer $PM_{2.5}$ changes in Tehran, in years 2012(a), 2013 (b), 2014 (c) and 2015 (d)

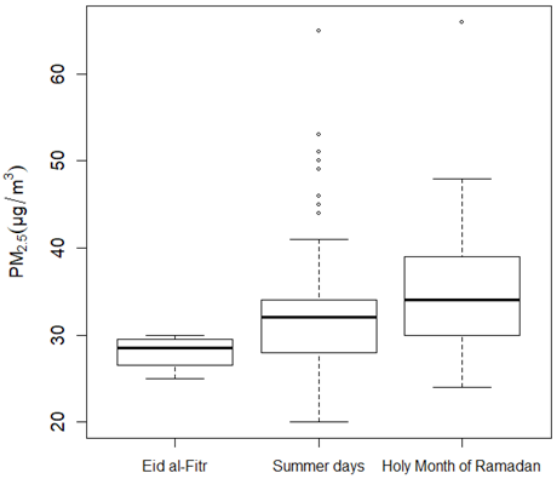

Fig. 4. Box plot of $PM_{2.5}$ concentrations of Tehran in Ramadan compared to summer days

Fig. 4 shows the box plots used to determine the effect of Ramadan on the $PM_{2.5}$ in Tehran. According to Fig. 4, the mean of $PM_{2.5}$ during Ramadan is higher compared to the other summer days. The main reason is dust storms during Ramadan, which caused lots of fluctuations in $PM_{2.5}$ concentration. Therefore, the $PM_{2.5}$ during Ramadan days has not been reduced, but also observed more. The Mann - Whitney test compares the mean of the two groups (the month of Ramadan and other summer days) for $PM_{2.5}$ concentrations. Statistical results using Mann - Whitney test showed significant differences in the mean of $PM_{2.5}$ levels between holy month of Ramadan and the other summer days ($P_{value} < 0.001$) with 95 % significance. The mean concentration levels was (M= 32.2 µg / m^3, SD = 6 in summer days; M = 34.6 µg / m^3, SD = 6.32 holy month of Ramadan).

Muharram

Muharram is another lunar month which is special to Muslims for the Ashura in Karbala. Mourning ceremony is held on10 first days of Muharram and most of people participate in this ceremony especially on days 9th and 10th of Muharram which are holidays. Fig. 3 shows the effect of 10 first days of Muharram on $PM_{2.5}$ in Tehran. According to Fig. 3, it can be seen that in the last days of Muharram (days 9th and 10th), $PM_{2.5}$ concentrations can be as little as possible which is mostly due to the final two days of the Muharram.

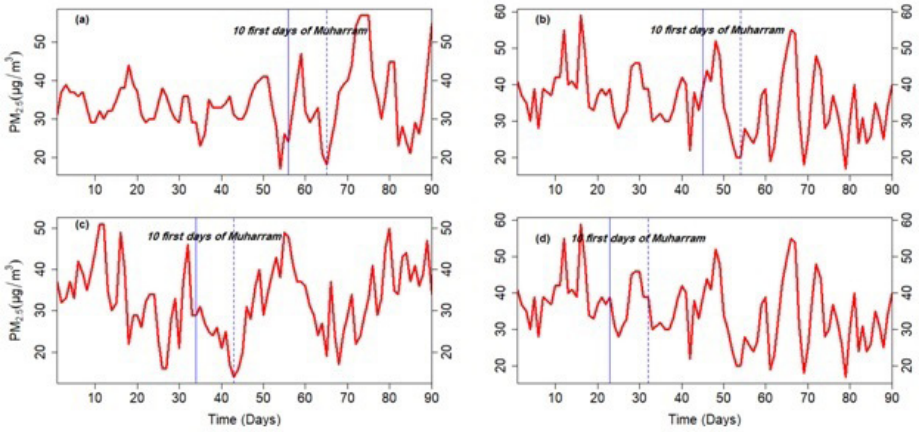

Fig. 5. Autumn $PM_{2.5}$ changes in Tehran, in years 2012 (a), 2013 (b), 2014 (c) and 2015 (d)

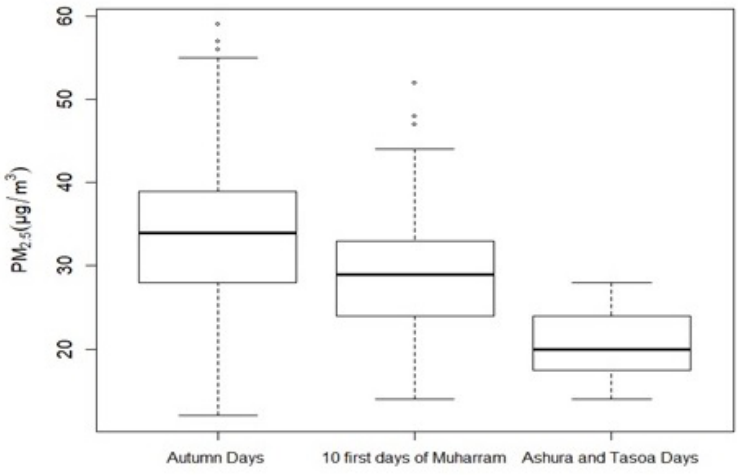

Fig. 6. Box plot of $PM_{2.5}$ concentrations of Tehran in Ashura compared to autumn days

In order to determine the effect of Ashura on $PM_{2.5}$ in Tehran's, a box plot was used as shown in Fig. 6. The mean concentration of $PM_{2.5}$ in Ashura is lower than the mean concentration of the other autumn days. Considering that the highest thermal inversions occur during autumn and winter, high concentration of particulate matters is usually observed. The occurrence of Ashura in autumn has reduced the $PM_{2.5}$, which represents the culture and customs of the people in Muharram and Ashura. The Mann - Whitney test compares the mean of two groups (10 first days of Muharram and other autumn days) for $PM_{2.5}$ concentration. Statistical results using Mann-Whitney test showed significant differences in the mean $PM_{2.5}$ levels between 10 first days of Muharram and other autumn days ($P_{value} < 0.01$) with 95 % significance. The mean concentration levels was (M = 34.18 μg / m^3, SD = 8.9 in autumn days; M= 30 μg / m^3, SD = 8.7 10 first days of Muharram). Fig. 7 compares the effect of events on $PM_{2.5}$ concentrations during the study period. As can clearly be seen in the Fig. 7, the highest effect of event on $PM_{2.5}$ concentrations was shown during Ashora and Tasoa days, whereas the lowest effect was found over the month of Ramadan. The median $PM_{2.5}$ concentrations on Ashora and Tasoa days and Ramadan where 20 and 34 μg / m^3 respectively.

Effect of season on $PM_{2.5}$

Air pollution in Tehran is usually caused by a variety of sources, but the main source is fuel combustion in motor vehicles. Several studies have reported that the ignition of vehicles is the main source of particulate matters in Tehran. Since the vehicle traffics are usually fluctuated during weekdays and are usually less at weekends, emissions of $PM_{2.5}$ will be less at weekends. The level of emission can be different in seasons. Fig. 7 represents the effect of seasons according to the information obtained from Tehran Air Quality Control from 2012 to 2015. Fig. 7 indicates that the concentration of $PM_{2.5}$ in the spring is less than the other seasons during the mentioned four years and plot mean is lower than general mean (30.45 μg / m^3). The overall range of concentrations of $PM_{2.5}$ is between 15 to 60 μg / m^3 in spring be-

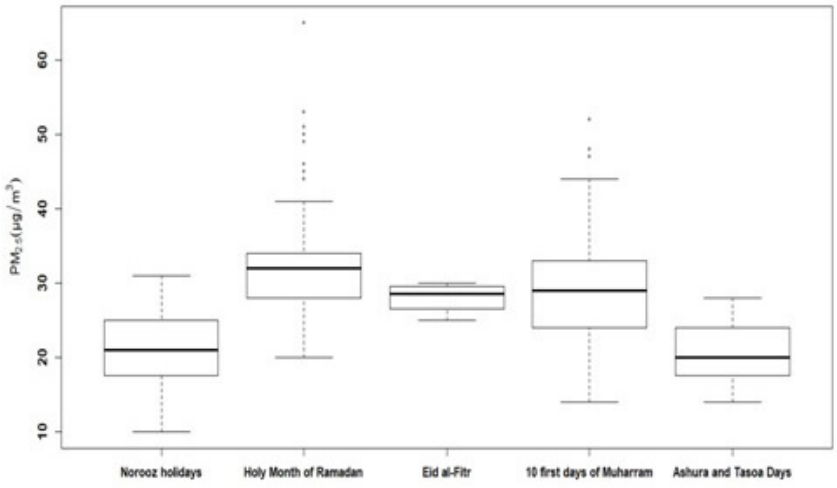

Fig. 7. Box plot of $PM_{2.5}$ concentrations of Tehran in all events

cause of the unstable conditions. In summer, plot mean is higher than general mean (34.15 µg / m^3), so $PM_{2.5}$ concentrations is higher than spring and daily range of $PM_{2.5}$ is 25 to 60 µg / m^3). Increasing this value in summer is more than spring due to the seasonal dust storms. In the autumn, data mean is consistent with general mean (33.54 µg / m^3) but most of the data recorded in this season is in the range between 35 to 60 µg / m^3.

Due to the thermal inversion and stable conditions in winter, pollution concentrations are much higher than the other seasons and the data mean is more than general mean (35.64 µg / m^3). The concentration of $PM_{2.5}$ is between 30 to 60 µg / m^3 in winter. Kruskal - Wallis test was used to compare difference in $PM_{2.5}$ concentration in each season. The results are shown in Table 1 and Fig. 8

A combination of box plots, density plot, and rug plot is used. The long line on each bean is the mean of observations, the short black bars represents each data point, and the shape of the bean is a mirrored density curve. The dotted horizontal line across the plot is set to overall mean [23].

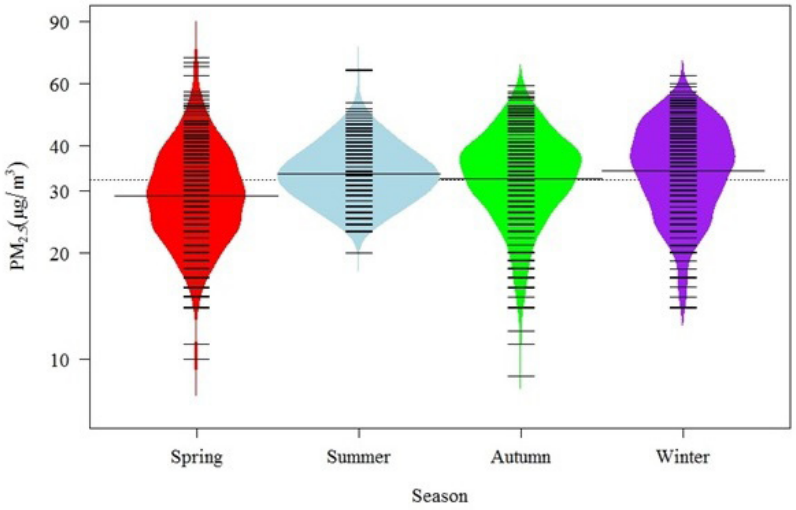

Fig. 8. Seasonal concentration of $PM_{2.5}$ bean plot in the air of Tehran, 2012 to 2015

Table 1. The Kruskal-Wallis test analysis for seasonal of $PM_{2.5}$ concentrations

Season	Obs.dif	Critical.dif	Difference
Autumn-Spring	207.85122	90.70397	TRUE
Autumn-Summer	36.99887	90.65271	FALSE
Autumn-Winter	99.38488	90.65271	TRUE
Spring-Summer	244.85009	90.70397	TRUE
Spring-Winter	307.23610	90.70397	TRUE
Summer-Winter	62.38600	90.65271	FALSE

*(P < 0.05) values were based on Kruskal-Wallis test

Based on Kruskal - Wallis test analysis the difference in $PM_{2.5}$ concentrations in seasons were significant (spring - autumn, $P_{value} < 0.05$; winter-autumn, $P_{value} < 0.05$ and summer-spring and winter - spring $P_{value} < 0.05$) , but only between summer-autumn ($P_{value} > 0.05$) and winter-summer ($P_{value} > 0.05$) was not significant.

Holidays effect on $PM_{2.5}$ concentrations according to seasons

As Thursdays and Fridays in Iran are holidays, it is expected that traffic would be low over the weekend, and concentration of $PM_{2.5}$ decreases. Table 1 listed daily descriptive statistical parameters in each season and the effect of holidays on the parameters.

In the spring, the mean concentration of $PM_{2.5}$ was approximately 30.45 µg / m^3, while on holidays the mean of particle concentration is 29 µg / m^3. It means that holidays in spring time can reduce the concentration of these particles about 6.38 %. If the holiday is two days or more, the mean concentration is 25 µg / m^3. It means that in the spring the concentration of $PM_{2.5}$ decreased by value of 18.43 %. The impact of holidays by one day and two days off are the same in summer and can reduce the concentration of $PM_{2.5}$ almost 2.76 %. In autumn the effect of holidays on concentration reduction is 2.29 % and if the holiday is over two days, the effect is 14.5 %. Due to cold weather and stable conditions in winter, holidays don't have any positive effect on reducing the concentration of $PM_{2.5}$, but just if the holiday is over two days, the mean reduction in the concentration of $PM_{2.5}$ is 9.85 %.

Table 2. Descriptive statistical analysis of $PM_{2.5}$ in normal days, holidays and holidays over two days off in different season of 2012 - 2015 in Tehran

Season	Type of days	Statistical descriptive analysis					
		Mean	Median	Min	Max	Change mean (percent)	P_{values}
Spring	days	30.45	29	10	71	-	-
	holidays	29	29	10	71	-6.38	0.06726
	Two consecutive holidays	25	25	10	49	-18.43	0.0001016
Summer	days	33.94	33	20	66	-	-
	holidays	33	33	24	53	-2.76	0.4229
	Two consecutive holidays	33	33	25	44	-2.76	0.4695
Autumn	days	33.75	33.5	9	59	-	-
	holidays	32	32	41	55	-2.29	0.06796
	Two consecutive holidays	28	28	14	44	-14.5	0.001114
Winter	days	35.55	35.5	14	63	-	-
	holidays	36	36	14	55	+1.26	0.8547
	Two consecutive holidays	32	36	14	46	-9.85	0.138

*P_{values} were based on Mann - Whitney test

CONCLUSIONS

In the present study, the data was gathered from air quality monitoring stations of Tehran municipality and the department of environment during 2012 - 2015 and the effect of events such as Norooz, Ramadan, Ashura and the weekly holiday on the concentration of $PM_{2.5}$ μm in each season were analyzed by R. Due to lack of similar studies in this field, It was not possible to compare the results to the other studies. Results obtained in the present study can be used to manage the health effects of $PM_{2.5}$ in any season. Results of this study are as follows:

1) In the process of reviewing of four-year concentrations, Norooz holidays have effect on reducing the concentration of PM2.5. The main reason of this reduction is decrease in traffic, residents travel and doesn't exist of daily trips from close cities to Tehran as well as the closure of universities, schools and other busy places of the city. It should be noted that the Norooz holiday is in spring, in this season the weather conditions are unstable, so the effect of this event is well appearing.

2) Ramadan had a negative effect on reducing $PM_{2.5}$ concentration in Tehran, so that the study of last day of this event at the summer, which coincides with Eid al - Fitr, shows that the concentration of $PM_{2.5}$ reaches to minimum.

3) Ashura, which is held in autumn in the study year, had a good effect on decreasing the level on $PM_{2.5}$ concentrations, while latter days of this event had a great reduction in $PM_{2.5}$ concentration.

4) According to this study, weekly holidays in any season were not a great effect on reducing the concentration of particles in winter due to the stability of air. One day holiday in winter has no significant effect on $PM_{2.5}$ concentrations, but two or more days holiday have remarkable effect. Thermal inversion and stability of air in winter, are considerable in obtaining the mentioned results.

FINANCIAL SUPPORTS

The authors received no financial supports for this study competing interests.

COMPETING INTERESTS

The authors declare there is no conflict of interest.

ACKNOWLEDGEMENTS

The authors are grateful to Tehran Air Quality Control Company for providing $PM_{2.5}$ concentrations data.

ETHICAL CONSIDERATIONS

All of the ethical issues have been completely observed by the authors

REFERENCES

[1] Cooper CD, Alley FC. Air pollution control: A design approach: Waveland Press; 2010.

[2] Seinfeld JH, Pandis SN. Atmospheric chemistry and physics: from air pollution to climate change. John Wiley & Sons; 2012.

[3] Naddafi K, Hassanvand MS, Yunesian M, Momeniha F, Nabizadeh R, Faridi S, et al. Health impact assessment of air pollution in megacity of Tehran, Iran. Iranian journal of environmental health science & engineering,2012.9(1):28.

[4] Azizi MH. Impact of traffic-related air pollution on public health: a real challenge. Archives of Iranian medicine. 2011.14(2):139.

[5] Nabi Bidhendi G, Halek F. Aerosol size segregated of Tehran's atmosphere in Iran. Int J Environ Res, 2007.1(1):58-65.

[6] Halek F, Kavousi-rahim A. GIS ASSESSMENT OF THE PM10, PM2.5 AND PM1.0 CONCENTRATIONS IN URBAN AREA OF TEHRAN IN WARM AND COLD SEASONS. The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 2014.40(2):141.

[7] Halek F, Kianpour-Rad M, Kavousirahim A. Parametric evaluation of indoor particulate matters in elementary schools in the central parts of Tehran. Indoor and Built Environment, 2013.22(3):580-5.

[8] Alizadeh-Choobari O, Bidokhti A, Ghafarian P, Najafi M. Temporal and spatial variations of particulate mat-

ter and gaseous pollutants in the urban area of Tehran. Atmospheric Environment, 2016.141:443-53.
[9] Ye C, Chen R, Chen M. The impacts of Chinese Nian culture on air pollution. Journal of Cleaner Production. 2016.112:1740-5.
[10] Tan P-H, Chou C, Liang J-Y, Chou CC-K, Shiu C-J. Air pollution "holiday effect" resulting from the Chinese New Year. Atmospheric Environment, 2009.43(13):2114-24.
[11] Tan P-H, Chou C, Chou CC-K. Impact of urbanization on the air pollution "holiday effect" in Taiwan. Atmospheric environment, 2013.70:361-75.
[12] Zheng Y, Che H, Zhao T, Zhao H, Gui K, Sun T, et al. Aerosol optical properties observation and its relationship to meteorological conditions and emission during the Chinese National Day and Spring Festival holiday in Beijing. Atmospheric Research. 2017.197:188-200.
[13] Zhang Y, Wei J, Tang A, Zheng A, Shao Z, Liu X. Chemical Characteristics of PM2. 5 during 2015 Spring Festival in Beijing, China. Aerosol and Air Quality Research, 2017.17(5):1169-80.
[14] Pleijel H, Grundström M, Karlsson GP, Karlsson PE, Chen D. A method to assess the inter-annual weather-dependent variability in air pollution concentration and deposition based on weather typing. Atmospheric Environment. 2016.126:200-10.
[15] Brönnimann S, Neu U. Weekend-weekday differences of near-surface ozone concentrations in Switzerland for different meteorological conditions. Atmospheric Environment, 1997.31(8):1127-35.
[16] Beirle S, Platt U, Wenig M, Wagner T. Weekly cycle of NO2 by GOME measurements: A signature of anthropogenic sources. Atmospheric Chemistry and Physics, 2003.3(6):2225-32.
[17] Forster PMdF, Solomon S. Observations of a "weekend effect" in diurnal temperature range. Proceedings of the National Academy of Sciences, 2003.100(20):11225-30.
[18] Latha KM, Badarinath K. Black carbon aerosols over tropical urban environment—a case study. Atmospheric Research,2003.69(1):125-33.
[19] Morawska L, Jayaratne E, Mengersen K, Jamriska M, Thomas S. Differences in airborne particle and gaseous concentrations in urban air between weekdays and weekends. Atmospheric Environment,2002.36(27):4375-83.
[20] Sadanaga Y, Sengen M, Takenaka N, Bandow H. Analyses of the ozone weekend effect in Tokyo, Japan: regime of oxidant (O3 + NO2) production. Aerosol Air Qual Res. 2012;12(2):161-8.
[21] Saadatabadi A, Bidokhti A. Urbanization effects on local climate in Tehran Megapolis. Research Journal of Environmental Sciences, 2011.5(1):1-21.
[22] Hassoun AA, Al-Arouj M, Ibrahim M. The effect of vildagliptin relative to sulfonylurea as dual therapy with metformin (or as monotherapy) in Muslim patients with type 2 diabetes fasting during Ramadan in the Middle East: the VIRTUE study. Current medical research and opinion, 2017.33(1):161-7.
[23] Amini H, Hosseini V, Schindler C, Hassankhany H, Yunesian M, Henderson SB, et al. Spatiotemporal description of BTEX volatile organic compounds in a Middle Eastern megacity: Tehran Study of Exposure Prediction for Environmental Health Research (Tehran SEPEHR). Environmental Pollution, 2017.226:219-29.