

# Exposure to Particulate Matter and its Health Impacts (an AirQ Approach)

Seyed Mohammad Daryanoosh<sup>a</sup>, Gholamreza Goudarzi<sup>b,c</sup>, Mohammad Javad Mohammadi<sup>d,e</sup>,  
Houshang Armin<sup>f</sup>, Yusef Omid Khaniabadi<sup>g\*</sup>, Shahram Sadeghi<sup>h</sup>

<sup>a</sup>Health Center of Hendijan, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

<sup>b</sup>Air Pollution and Respiratory Diseases Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

<sup>c</sup>Environmental Technologies Research Center (ETRC), Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

<sup>d</sup>Abadan School of Medical Sciences, Abadan, Iran.

<sup>e</sup>Student Research Committee, Department of Environmental Health Engineering, School of Public Health and Environmental Technologies Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

<sup>f</sup>Ilam University of Medical Sciences, Ilam, Iran.

<sup>g</sup>Health Care System of Karoon, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

<sup>h</sup>Environmental Health Research Center, Kurdistan University of Medical Sciences, Sanandaj, Iran.

\*Correspondence should be addressed to Mr. Yusef Omid Khaniabadi; Email: [yusef\\_omidi@yahoo.com](mailto:yusef_omidi@yahoo.com)

## A-R-T-I-C-L-E-I-N-F-O

### Article Notes:

Received: Aug 21, 2016

Received in revised form:

Nov 24, 2016

Accepted: Dec 22, 2016

Available Online: Jan 1,  
2017

### Keywords:

Heart disease

Software

Particulate matter

Respiration disorders

Iran

## A-B-S-T-R-A-C-T

**Background & Aims of the Study:** Recent studies indicated that particulate matter can have the lung irritation, chronic lung diseases, lung tissue, etc. The aim objective of this study was to assess the mortality associated with exposure to PM<sub>10</sub> concentrations in Ilam, Iran, during 2013.

**Materials & Methods:** PM<sub>10</sub> data were taken from Ilam's Local Agency of Environment (I-LAE). The annual mortality, including total, cardiovascular, and respiratory due to PM<sub>10</sub> were estimated, using AirQ2.2.3 software model. The relative risk (RR) and baseline incidence (BI) defaulted by WHO were used for this purpose.

**Results:** The number of excess cases for total, cardiovascular and respiratory mortality was estimated 161, 85 and 17 persons, respectively for a year exposure to PM<sub>10</sub> among the people. About 3.95% of mortalities were occurred in the days with concentration levels less than 20 µg/m<sup>3</sup>. The most percentage of person-days attributed to different levels of PM<sub>10</sub> was found to be in concentration of 40-49 µg/m<sup>3</sup>.

**Conclusions:** In order to diminish the health impacts of particulate matter in Ilam city, health training by health systems should be conducted to public people especially persons with chronic lung and heart diseases, elderly and children to reduce their activities in the dusty days.

**Please cite this article as:** Daryanoosh SM, Goudarzi G, Mohammadi MJ, Armin H, Omid Khaniabadi Y, Sadeghi S. Exposure to Particulate Matter and its Health Impacts (an AirQ Approach). Arch Hyg Sci 2017;6(1):88-95.

## Background

Air pollution due to industrialization, population, and urbanization is an important environmental problem in the world, especially in developing countries (1-4). World Health Organization (WHO) approximated that about 800,000 cardiovascular and respiratory death occurred per each year in the world due to urban air pollution (5-8). Epidemiological

studies showed that air pollution, especially particulate matter (PM<sub>10</sub>) has a serious impact on the human health (9-12). PM<sub>10</sub> can penetrate into the airways where they may exert adverse effects (13-15). Numerous epidemiological studies also have shown an association between PM<sub>10</sub> concentration in ambient air and respiratory diseases, pulmonary sicknesses, and mortality among the exposed population (16-18). In a study conducted by WHO, the results

showed that an increase of  $10 \mu\text{g}/\text{m}^3$  in particulate matter level can lead to an increase of 1-3% in mortality rate (19-21). Epidemiological researches also illustrated that higher than 500,000 deaths each year occurred due to cardiovascular diseases associated with  $\text{PM}_{10}$  (16,22).

Ilam, the capital city of Ilam province, a western city of Iran, is encountered to high quantities of air particulate matter. In the recent years, because of the Middle Eastern Dust (MED) storms especially from the Arabian Peninsula, Kuwait and Iraq, the areas of south, west and southwest of Iran have been influenced because of exposure to  $\text{PM}_{10}$ . MED storms have led to thousands of hospitalizations due to cardiopulmonary diseases (23). The Air Quality Health Impact Assessment (AirQ2.2.3) software is a program that has been used to assess the health impact of  $\text{PM}_{10}$  (9,20,24). This model is a valid and reliable tool proposed by WHO in order to estimate the potential of short-term impacts of air pollution on the human

health. Several studies have been conducted by Nourmoradi *et al.* (16,23), Zhou *et al.* (25), Shakour *et al.* (13), Gharehchahi *et al.* (26), Schwartz *et al.* (14), Dockery *et al.* (27), Mohammadi *et al.* (28), Chen *et al.* (29) and Martuzzi *et al.* (19) to assess the air quality in terms of particulate matter and its health risks on the human.

#### Aims of the study:

In the present study, the AirQ2.2.3 software was applied to assess the total, cardiovascular and respiratory mortality attributed to  $\text{PM}_{10}$  in Ilam, during 2013.

### Materials & Methods

#### Study area

Ilam ( $33^{\circ}36'N$ ,  $46^{\circ}36'E$ ), the capital of Ilam province and a western Iranian city has a total population of 170,000 persons. Ilam is developing and non-industrialized. Fig. 1 shows the location of Ilam and sampling station.



Figure 1) The study area and sampling station

#### Health impacts

Daily data of  $\text{PM}_{10}$  during 2013 were obtained from air pollution-monitoring station of Ilam's Local Agency of Environment (I-LAE). The AirQ is a tool that advanced by WHO European Center for Environment and Health for estimation of health impact of air pollution

(30,31). This program is utilized to assess the health impact of exposure to air pollution (32). The association is based on the attributable proportion (AP), which is defined as the portion of the health result in a certain residents attributable to contact to a given air pollutant (30,33). The AP is calculated by Eq. (1):

$$AP = \frac{\sum([RR(c) - 1] * P(c))}{\sum[RR(c) * P(c)]}$$

(1)

Where; AP and RR (cc) are attributable proportion of the health endpoint and the relative risk for a certain health impact in group c of exposure, respiratory (16,34). Moreover, P (c) is the proportion of the target population in exposed group (24). The amount of attributable to the population exposure can be founded by following equation, if the baseline frequency of the health impact in the studied population is identified.

$$IE = I * AP \quad (2)$$

Where; IE and I are the amounts of the health impact attributable to the exposure and the baseline frequency of the health endpoint in the population, respectively. Finally, considering the population size, the number of excess cases attributable to the exposure can be identified by Eq. (3).

$$NE = IE * N \quad (3)$$

Where; NE is the number of person attributed to the exposure and N is the total number of assessed residents. The RR gives increase in possibility of adverse endpoint associated with a given change in the exposure levels, comes from time-series studies where day-today changes in air pollutants over long periods were relation to daily mortality, hospital admissions and other public health indicators (30).

### Inputs adjustment

Daily averages of PM<sub>10</sub> were used in this study to assess the health impact in Ilam. The mortality rates associated with PM<sub>10</sub> were estimated using AirQ Version: 2.2.3. Finally, the numbers of persons for total, cardiovascular, and respiratory mortality were calculated. The values of RR and BI were taken from the studies of Khaniabadi et al (24) and Shahsavani et al (9).

## Results

The highest and the lowest concentrations of PM<sub>10</sub> in Ilam are presented in Table 1. As seen, the annual average of PM<sub>10</sub> was equal to 77.67 µg/m<sup>3</sup>, during 2013. The summer average of PM<sub>10</sub> with an amount of 88.57 µg/m<sup>3</sup> was higher than winter with an average equal to 55.85 µg/m<sup>3</sup>. The annual maximum concentration of PM<sub>10</sub> in the summer was higher than winter, with the observed maximum concentration of 491 µg/m<sup>3</sup> in the summer.

**Table 1) The highest and the lowest concentrations of PM<sub>10</sub> in Ilam.**

Parameters	Value (µg/m <sup>3</sup> )
Annual average	77.67
Summer average	88.57
Winter average	55.85
Annual maximum	491.0
Summer maximum	491.0
Winter maximum	194.63
98 percentile	257.6

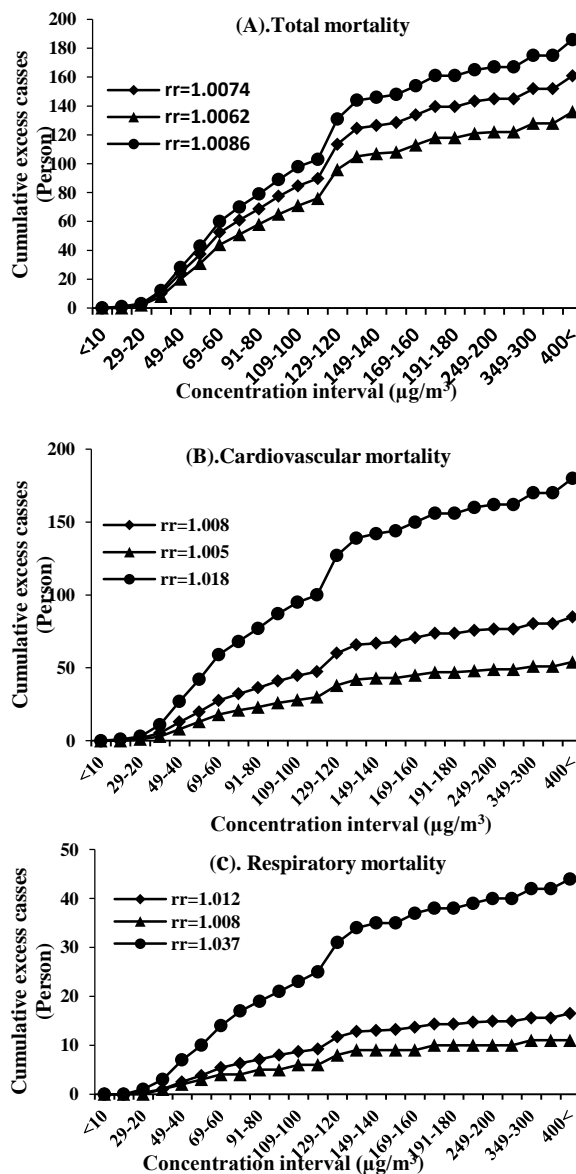
Table 2 shows the relationship between PM<sub>10</sub> concentrations and percentage of attributed proportion; also, the number of persons suffering from total, cardiovascular and mortality due to respiratory diseases according to the relative risk (RR) and baseline incidence (BI) proposed by WHO. As it can be seen, the cumulative number of estimated excess cases for total mortality was about 161 persons. Moreover, as shown in this table, the cumulative number of estimated excess cases for cardiovascular and respiratory mortality was 85 and 17 persons, respectively.

**Table 2) Relationship between relative risk (RR), attributable proportion (AP), and cumulative number of excess cases (Part/billion).**

Short-term effect	BI*	RR **	Estimated AP (%)	Cumulative number of excess cases
<b>Total mortality</b>	543.5	1.0074 (1.0062-1.0086)	4.6568 (3.9313-5.3714)	161 (131-186)
<b>Cardiovascular mortality</b>	231	1.0080 (1.0050-1.0180)	5.0154 (3.1947-10.6189)	85 (55-180)
<b>Respiratory mortality</b>	48.4	1.0120 (1.0080-1.0370)	7.3391 (5.0154-19.6277)	17 (12-45)

\*BI=baseline incidence, \*\*RR=relative risk

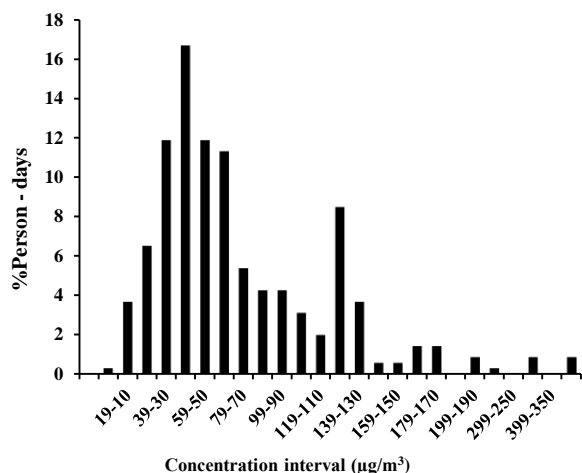
Fig. 2 indicates the results of quantification of health impacts and the number of consequences obtained from the software explicated versus PM<sub>10</sub> concentration interval in Ilam. Fig. 2 also shows charts based on the cumulative number of each health outcome and the number of excess cases in three styles (5, 50, and 95% RR). There are three curves for each chart (include lower, medium, and upper). The middle curve is corresponds to a RR of centerline. Lower curve is in relation to a RR of 5% (underestimate), and the upper curve is associated with a 95% RR (overestimate). Based on Fig. 2, the cumulative number of total death, cardiovascular death, and respiratory mortality in central relative risk is calculated equal to 161, 85, and 17 persons in Ilam, respectively. In addition, there is a steep increase in concentrations of higher than 120 µg/m<sup>3</sup> related to the charts from estimated health effects. Moreover, about 3.95% of mortality rates associated with PM<sub>10</sub> was happened in the days with concentration less than 20 µg/m<sup>3</sup>, and 81.07% of these effects occurred due to PM<sub>10</sub> concentration lower than 120 µg/m<sup>3</sup>. More than 98% of cumulative number of total, cardiovascular, and respiratory mortality was occurred in the days with PM<sub>10</sub> concentration not exceeding 200 µg/m<sup>3</sup> in Ilam.



**Figure 2) The quantification of health effects versus PM<sub>10</sub> concentration (A, B,C)**



Fig. 3 illustrates the percentage of time that people in Ilam were exposed to different concentrations of PM<sub>10</sub> that led to health effect among affected groups. Based on this figure, the most percentage of person-days related to different level of PM<sub>10</sub> was found to be in the concentration of 40-49 μg/m<sup>3</sup>, which resulted to health impacts in Ilam.



caused to the health impacts in Ilam. Fattore et al. (2011) illustrated that the most percentage of days that people in Milano were exposed to different PM<sub>10</sub> levels was in concentration interval of 40-49 µg/m<sup>3</sup>. This result also is in consistent with the results of Hosseini et al (2014) in Sanandaj, Iran, during 2013 (22).

## Conclusion

In this study AirQ2.2.3 software and the approach proposed by World Health Organization (WHO) have been used to provide quantitative data on impact of PM<sub>10</sub> on the health of people living in a certain area. The results show that cardiovascular mortality has an important role in the cumulative number of total mortality. The results also are in line with those of other researches and despite the limitations, indicate that this method offers an effective and easy tool, helpful in decision-making. In addition, further researches with specific RR and BI according to geographical, climatic and statistical features are required. In order to diminish the health impacts of particulate matter in Ilam city, health training by health care systems should be conducted to public people especially persons with chronic lung and heart diseases, elderly and children. Furthermore, the attempts should be conducted in the governmental scale in order to control of Middle Eastern dust storms (MED) sources.

## Footnotes

### Acknowledgments:

The authors wish to thank the Ilam's Local Agency of Environment (I-LAE).

### Funding/Support

This study was financially supported by Ahvaz Jundishapur University of Medical Sciences.

### Conflict of Interest:

The authors stated no conflict of interest.

## References

1. Goudarzi G, Geravandi S, Mohammadi MJ, Salmanzadeh S, Vosoughi M, Sahebalzaman M. The

relationship between air pollution exposure and chronic obstructive pulmonary disease in Ahvaz, Iran. *Chron Dis J* 2015;3(1):14-20.

2. Yari AR, Goudarzi G, Geravandi S, Dobaradaran S, Yousefi F, Idani E, et al. Study of ground-level ozone and its health risk assessment in residents in Ahvaz City, Iran during 2013, . *Toxin Rev.* 2016;35(3-4):201-6, DOI: 10.1080/15569543.2016.1225769.

3. Gloennec P, Monroux F. Health impacts assessment of PM<sub>10</sub> exposure in the city of Caen, France: Is eliminating air pollution peaks enough? *Health Impacts assessment of PM<sub>10</sub> exposure. J Toxic Environ Health* 2007;70:359-64.

4. Sepahvand A, Godini H, Omid Y, Tarrahi M, Rashidi R, Basiri H. Investigation of Fungal Bioaerosols and Particulate Matter in the Teaching-Medical Hospitals of Khorramabad City, Iran During 2015. *Iranian J Health Environ* 2016;9(1):115-26.

5. Menetrez MY, Foarde KK, Esch PK, Schwartz TD, Dean TR, Hays MD, et al. An evaluation of indoor and outdoor biological particulate matter. *Atmos Environ* 2009;43(34):5476-83.

6. Wang S, Feng X, Zeng X, Ma Y, Shang K. A study on variations of concentrations of particulate matter with different sizes in Lanzhou, China. *Atmos Environ* 2009;43(17):2823-8.

7. Mirhosseini SH, Birjandi M, Zare MR, Fatehizadeh A. Analysis of Particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>) concentration in Khorramabad city. *Int J Environ Health Eng* 2013;2(3):1-4.

8. Yari AR, Goudarzi G, Geravandi S, Dobaradaran S, Yousefi F, Idani E, et al. Study of ground-level ozone and its health risk assessment in residents in Ahvaz City, Iran during 2013, . *Toxin Rev.* 2016;35(3-4):201-6, DOI: 10.1080/15569543.2016.1225769.

4. Sicard P, Lesne O, Alexandre N, Mangin A, Collomp R. Air Quality Trends and Potential Health Effects - Development of an Aggregate Risk Index. *Atmospheric Environment* 2011;45:1145-53.

9. Shahsavani A, Naddafi K, Jafarzade Haghighifard N, Mesdaghinia A, Yunesian M, Nabizadeh R, et al. The evaluation of PM<sub>10</sub>, PM<sub>2.5</sub>, and PM<sub>1</sub> concentrations during the Middle Eastern Dust (MED) events in Ahvaz, Iran, from april through september 2010. *J Arid Environ.* 2012;77:72-83.

10. Pirsahab M, Zinatizadeh A, Khosravi T, Atafar Z, Dezfulinezhad S. Natural Airborne Dust and Heavy Metals: A Case Study for Kermanshah, Western Iran (2005-2011). *Iranian J Pub Health* 2014;43(4):460-70.

11. Weuve J, Puett R, Schwartz J, Yanosky J, Laden F, Grodstein F. Exposure to particulate air pollution and cognitive decline in olderwomen. *Arch Intern Med* 2012;172(3):219-27.

12. Daryanoosh SM, Goudarzi G, Harbizadeh A, Heshmatollah, Nourmoradi, Vaisi AA, et al. Hospital

Admission for Respiratory and Cardiovascular Diseases Due to Particulate Matter in Ilam, Iran. *Jundishapur J Health Sci* 2017;9(1):e36106.

13. Shakour AA, El-Shahat MF, El-Taieb NM, Hassanein MA, Mohamed AMF. Health impacts of particulate matter in greater Cairo, Egypt. *J Am Sci* 2011;7(9):840-8.

14. Schwartz J, Slater D, Larson TV, Pierson WE, Koenig JQ. Particulate air pollution and hospital emergency room visits for asthma in Seattle. *Am Rev Respir Dis* 1993;174(4): 826-31.

15. Khaniabadi YO, Goudarzi G, Daryanoosh SM, Borgini A, Tittarelli A, De Marco A. Exposure to PM<sub>10</sub>, NO<sub>2</sub>, and O<sub>3</sub> and impacts on human health. *Environ Sci Pollut Res* 2016.

16. Nourmoradi H, Goudarzi G, Daryanoosh SM, Omid-Khaniabadi F, Jourvand M, Omid-Khaniabadi Y. Health impacts of particulate matter in air by AirQ model in Khorramabad city, Iran. *J Bas Res Med Sci* 2015;2(2):44-52.

17. Nourmoradi H, Omid-khaniabadi Y, Goudarzi G, Jourvand M, Nikmehr K. Investigation on the Dust Dispersion (PM<sub>10</sub> and PM<sub>2.5</sub>) by Doroud Cement Plant and Study of Its Individual Exposure Rates. *J Ilam Univ Med Sci* 2016;24(1):64-75. (Full Text in Persian)

18. Khaniabadi YO, Daryanoosh SM, Amrane A, Polosa R, Hopke PK, Goudarzi G, et al. Impact of Middle Eastern Dust storms on human health. *Atmos Pollut Res* 2016.

19. Martuzzi M, Galassi C, Ostro B, Forastiere F, Bertollini R. Health Impact Assessment of Air Pollution in the Eight Major Italian Cities. *WHO Europ EURO /02/5040650*; 2002.

20. Tominz R, Mazzoleni B, Daris F. Estimate of potential health benefits of the reduction of air pollution with PM<sub>10</sub> in Trieste, Italy. *Epidemiol Prev* 2005;29(3-4):149-55.

21. Schlesinger RB, Kunzli N, Hidy GM, Gotschi T, Jerrett M. The health relevance of ambient particulate matter characteristics: Coherence of toxicological and epidemiological inferences. *Inhal Toxicol* 2006;18(2):95-125.

22. Hosseini G, Maleki A, Amini H, Mohammadi S, Hassanvand M, Gahi O, et al. Health impact assessment of particulate matter in Sanandaj, Kurdistan, Iran. *J Adv Environ Health Res* 2014;2(1):54-62.

23. Nourmoradi H, Khaniabadi YO, Goudarzi G, Daryanoosh SM, Khoshgoftar M, Omid F, et al. Air Quality and Health Risks Associated With Exposure to Particulate Matter: A Cross-Sectional Study in Khorramabad, Iran. *Health Scope* 2016;5(1):e31766.

24. Zallaghi E, Shirmardi M, Soleimani Z, Goudarzi G, Heidari-Farsani M, Al-Khamis G, et al. Assessment of health impacts attributed to PM<sub>10</sub> exposure during 2011

in Kermanshah City, Iran. *J Adv Environ Health Res* 2014;2(4):242-50.

25. Zhou M, Liu Y, Wang L, Kuang X, Xu X, Kan H. Particulate air pollution and mortality in a cohort of Chinese men. *Environ Pollut* 2014;186:1-6.

26. Gharehchahi E, Mahvi AH, Amini H, Nabizadeh R, Akhlaghi AA, Shamsipour M, et al. Health impact assessment of air pollution in Shiraz, Iran: a two-part study. *J Environ Health Sci Eng* 2013;11(11):11.

27. Dockery DW, Pope CA. Acute respiratory effects of particulate air pollution. *Annu Rev Public Health* 1994;15:107-32.

28. Mohammadi A, Azhdarpoor A, Shamsavani A, Tabatabaee H. Health impacts of exposure to PM<sub>10</sub> on inhabitants of Shiraz, Iran. *Health Scope* 2015;4(4):e31015.

29. Chen R, Pan G, Kan H, Tan J, Song W, Wu Z, et al. Ambient air pollution and daily mortality in Anshan, China: a time-stratified casecrossover analysis. *Sci Total Environ* 2010;408(24):6086-91.

30. Fattore E, Paiano V, Borgini A, Tittarelli A, Bertoldi M, Crosignani P, et al. Human health risk in relation to air quality in two municipalities in an industrialized area of Northern Italy. *Environ Res* 2011;111(8):1321-7.

31. Mohammadi MJ, Godini H, Khak MT, Daryanoosh SM, Dobaradaran S, Goudarzi G. An Association Between Air Quality and COPD in Ahvaz, Iran. *Jundishapur J Chronic Dis Care* 2015;4(1):1-6.

32. Omid Y, Goudarzi G, Heidari AM, Daryanoosh SM. Health impact assessment of short-term exposure to NO<sub>2</sub> in Kermanshah, Iran using AirQ model. *Environ Health Eng Manag J* 2016;3(2):91-7. (Full Text in Persian)

33. Khaniabadi YO, Hopke P, Goudarzi G, Daryanoosh S, Jourvand M, Basiri H. Cardiopulmonary mortality and COPD attributed to ambient ozone. *Environ Res* 2017;152:336-41

34. Daryanoosh SM, Goudarzi G, Khaniabadi YO, Armin H, Bassiri H, Khaniabadi FO. Effect of Exposure to PM<sub>10</sub> on Cardiovascular Diseases Hospitalizations in Ahvaz, Khorramabad and Ilam, Iran During 2014. *Iranian J Health Saf Environ* 2016;3(1):428-33.

35. Dehghani M, Anushiravani A, Hashemi H, Shamsedini N. Survey on Air Pollution and Cardiopulmonary Mortality in Shiraz from 2011 to 2012: An Analytical-Descriptive Study. *Int J Prev Med* 2014;5(6):734-40.

36. Jeong SJ. The Impact of Air Pollution on Human Health in Suwon City. *Asian J Atmos Environ* 2013;7-4:227-33.

37. Krzyzanowski M. Methods for assessing the Extent of Exposure and Effects of Air Pollution. *Occup Environ Med* 1997;54:145-51.

38. Geravandi G, Geravandi S, Mohammadi M, Saeidimehr S, Ghomaishi A, Salmanzadeh Sh. Health endpoints caused by PM10 Exposure in Ahvaz, Iran. *Iranian J Health Saf Environ* 2014;1(4):159-65.
39. Yavari A, Sotoudeh A, Parivar P. Urban Environmental Quality and Landscape Structure in Arid Mountain Environment. *Int J Environ Res* 2007;1(4):325-40.