



Homepage: www.jbiom.com

The Health Effects of Particulate Matter (PM2.5) in the Ambient Air of Urmia City, Iran

Amir Mohammadi¹, Saeed Mousavi², Sepideh Nemat³, Mojtaba Momtaz¹, Ali Abdollahnejad¹, Maryam Faraji^{4*}

1. Environmental Science and Technology Research Center, Department of Environmental Health Engineering, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
2. Environmental Research Center of West Azerbaijan, Urmia, Iran
3. Department of Environmental Health Engineering, School of Health, Student Research Center, Tabriz University of Medical Sciences, Tabriz, Iran
4. Department of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

ARTICLE INFO

ABSTRACT

ORIGINAL ARTICLE

DOI:

10.30468/JBIOM.2017.55952

Article History:

Receive Date: 2017-06-15

Accept Date: 2017-08-08

***Corresponding author**
Maryam Faraji

Email:

M_faraji28@yahoo

Tel:

ORCID iD:

0000-0002-7220-4438

Keywords:

*Urmia City, Air Pollution,
Urmia Lake, Health Effects*

International Agency for Research on Cancer (IARC) has defined outdoor air pollution as a mixture of particulate matters, specifically those that are considered carcinogenic to humans (IARC Group 1). Outdoor air pollution contains various pollutants that are resulted from natural and human sources. The present study aimed to evaluate exposure to particulate matter (PM2.5) and its effects on human health in the northwest of Iran during 2015-2016 using the AirQ model. Data were collected from online monitoring stations in Urmia city, and total mortality was estimated using the AirQ model. The annual mean PM2.5 concentrations was 23 $\mu\text{g}/\text{m}^3$, which was higher than the recommended limit (10 $\mu\text{g}/\text{m}^3$) by the World Health Organization (WHO). In addition, total mortality at the central relative risk of 1.015 was calculated to be 143 cases. The main sources of PM2.5 were the combustion of fossil fuels and also salty dust storms due to climate change and drying of Urmia Lake. Therefore, development of green spaces and extensive desertification activities are recommended for the control of this extremely challenging phenomenon.

Introduction

In recent years, air pollution due to anthropogenic activities and natural phenomena, such as dust storm, has been led to human mortality across the world. Although, air pollutants in concentrations lower than the standard level have insignificant adverse effects on health, they could threaten sensitive populations (1). Nowadays, there are growing concerns regarding the air pollution in cities due to the presence of harmful substances, such as O_3 , NO_2 , as well as the trend in the distribution and size of particulate matters in air (2, 3).

In the past two decades, several epidemiological studies have demonstrated that air pollution in cities can cause respiratory and cardiovascular diseases, chronic bronchitis, and even death (4, 5). In 2000, the global mortality rate associated with air pollution was reported to be one per a million, while in 2012, approximately 1.3 million deaths were reported due to air pollution, more than 50% of which occurred in Asia (6). Despite of unclear findings regarding the biological mechanisms of the air pollutants with significant effects on human health, these effects could be

attributed to the potential oxidation of the various parts of air cells or the active pathways inside cells (7).

According to reports of the World Health Organization (WHO), particles smaller than 10 micron (PM_{10}) could be influential factors in mortality and respiratory and cardiovascular diseases, such as asthma, bronchitis, cardiac arrest, and reduced pulmonary function. In some European cities, the mortality is mainly attributed to the air pollution mainly PM_{10} , so that increased PM_{10} concentration of $10 \mu g/m^3$ increases mortality by 6% (8).

With the remarkable development of urban areas and increased number of transportation vehicles in recent decades, the air quality in Iran has had a plunging trend. Several studies have confirmed severe air pollution levels in the cities in Iran, including Tehran, Isfahan, Arak, Mashhad, and Tabriz. Furthermore, PM_{10} is the main influential factor in the air pollution in these cities (9).

According to the studies in Delhi (India), Beijing (China), and some cities in Malaysia, air pollution is at an alarming rate in more than 80% of the days in a

year, and PM₁₀ is reported as main pollutant. There is similar status in Iran due to the presence of industries, transportation, and growing population; industries and urban traffic are considered to be the main sources of air pollution in Iran (10-13).

The present study aimed to assess the health effects of the particle matter smaller than 2.5 micron (PM_{2.5}) in the ambient air of Urmia city, Iran.

Materials and Methods

Studied Area

This descriptive-ecological study was done in Urmia city, the center of West Azerbaijan Province (Figure 1). Required data were obtained from the Environmental Office of West Azerbaijan province during March 2015-February 2016.

AirQ Software

The assessment of health effects of PM₁₀ was performed in accordance with the WHO guidelines (8) using the AirQ software version 2.2.3 (14). The software was designed to estimate the effects of pollutants on human health in a specific period and location and is accessible on the WHO website:

<http://www.euro.who.int/eprise/main/WHO/Progs/AIQ/activities/20050223> 5.

In AirQ software, calculations are performed based on the risk estimation from similar studies to determine the long-term effects of pollutants and risk estimation from chronological studies to determine the mortality and diseases associated with pollutants. This model was originally prepared for the Environmental Health in Central Europe; however, modification of the coefficients renders it useful for other countries as well. According to the information in Table 1, the coefficients of base incidence (BI) are calculated for the health effects of pollutants on various age groups. Considering that the Iranian population is younger than the European population, the values are smaller in our country (14). In AirQ software, attributable proportion (AP) is the level of exposure to air pollution in a specific population at a specific time, which is calculated based on the Equation 1:

$$AP = \frac{\sum \{ [RR(c) - 1] \times p(c) \}}{\sum [RR(c) \times p(c)]} \quad (1)$$

where RR(c) is the relative risk of the health impact in the target group, and p(c) represents the population of the target group. By determining the BI in the target population, rate of the health

outcome related to the exposure (IE) could be calculated using the Equation 2:

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

where I denotes the baseline frequency of the health endpoint in the population. Finally, the estimated number of cases attributed to the exposure (NE) in a population of 'N' could be determined using the Equation 3:

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

Exposure Assessment

Evaluation of exposure to PM_{2.5} during one year was performed in accordance with the WHO guidelines. Initially, the obtained data were processed in Microsoft Excel software on two levels, followed by the estimation of the average and maximum seasonal and yearly exposure level (98 percentiles annually) and determining two main pollutants.

The population of Urmia city in different age groups was obtained from the Statistical Center of Iran (736,224 people). Finally, the collected data were analyzed using the AirQ software in accordance with the guidelines of WHO. In addition, the AP, mortality rate, and disease rate associated with PM_{2.5} were determined.

Results and Discussion

The descriptive statistics of PM_{2.5} concentrations are depicted in Figure 2. The annual mean PM_{2.5} concentrations was 23 µg/m³, which was higher than the recommended limit (10 µg/m³) in the WHO guidelines. The maximum concentration of PM_{2.5} was estimated at 26 µg/m³ in winter. The most probable causes of the phenomenon were high-speed winds from the lake to the city in winter, combustion of fossil fuels in vehicles and residential areas. Highest monthly mean concentration was calculated to be 28 µg/m³ in March. The days on which the population of Urmia is exposed to PM_{2.5} concentrations are illustrated in Figure 3. According to this figure, the highest value of exposure to PM_{2.5} was 10-19 µg/m³ during 118 days. Therefore, it could be concluded that that the population of Urmia was exposed to higher PM_{2.5} concentrations than the recommended levels by the WHO.

Table 1 shows the estimated values in the AirQ model about the effects of PM_{2.5} on human health for total mortality due to respiratory diseases. According to our findings, the annual BI rate of total mortality in Urmia city was 403.82 per 100,000. Estimated cumulative total mortality is shown in Figure 4. Cumulative

excess cases for total mortality was estimated 143 cases under circumstances with the relative risk of air pollution.

According to the reports in two urban areas in Northern Italy, PM_{2.5} was the main influential factor in the health of inhabitants. In Trieste, a city in the northeast of Italy with 200,000 populations, short-term exposure to PM₁₀ at concentrations of >20 µg/m³ led to total mortality, cardiovascular mortality, and respiratory mortality in 52, 28, and six cases, respectively. Moreover, the findings indicated that 2.5% of respiratory mortalities and 1.8% of cardiovascular mortalities were associated with PM₁₀ concentrations of >20 µg/m³ (15). These findings are based on excess cases and consistent with the results of the present study in Urmia city (Iran).

In the other studies performed in 29 European cities, numerous Asian countries, and 20 American cities, it has been reported that the short-term adverse health effects due to the PM₁₀ exposure are similar in developing and

developed countries. On the other hand, the results were indicative of higher mortality rate by 0.72% when daily PM₁₀ concentrations increased by 10 µg/m³ (16-19).

Conclusion

According to the results, the concentration of PM_{2.5} was higher than the recommended values by the WHO during several months and days in Urmia city. The main sources of PM were incineration fossil fuels, salty dust storms caused by climate change, and drying of Urmia Lake. Therefore, it is suggested that extensive activities (e.g., desertification) be carried out to control this extremely challenging phenomenon. Considering the long-term impacts of such activities, some midterm and short-term strategies must also be adopted to overcome the severe issue of air pollution in Urmia city.

Acknowledgements

Hereby, we extend our gratitude to the Environmental Research Center and Environmental Office of West Azerbaijan province for assisting us in this project.

Table 1. Baseline Incidence (BI), Relative Risk (RR) with 95% Confidence Interval, Estimated Attributable Proportion (AP), and Number of Annual Excess Cases Due to Short-term Exposure to PM_{2.5} (>10 µg/m³)

Health Endpoints	Pollutant	BI*	RR (per 10 $\mu\text{g}/\text{m}^3$)	AP Percentage (Uncertainty Range)	Number of Excess Cases (Uncertainty Range)**
Total Mortality	PM _{2.5}	403.82	1.015 (1.011-1.019)	1.920 (1.415-2.420)	143 (105-180)

*Crude rate per 100,000 inhabitants per year; **obtained using lower and upper RR values

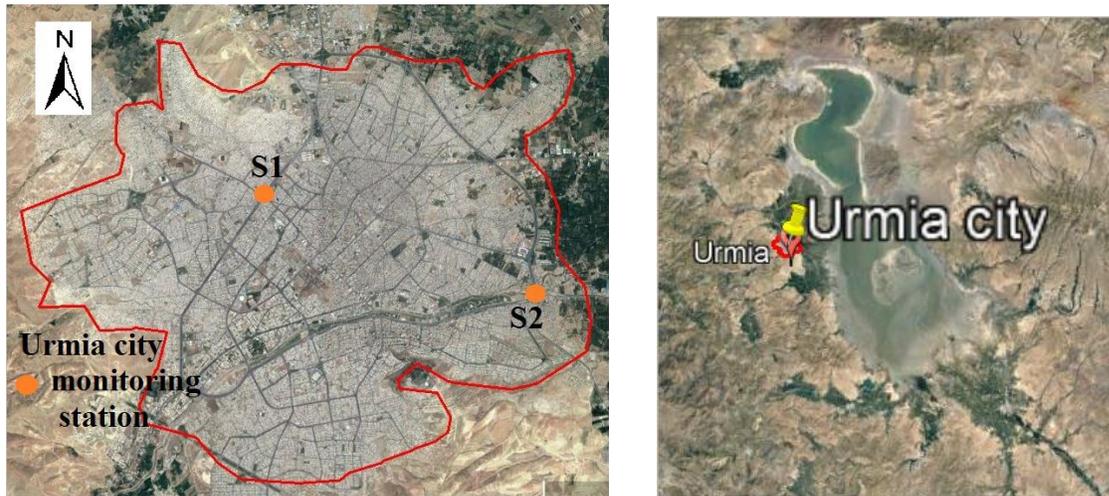


Figure 1. Map of Studied Area and Air Quality Monitoring Station (S1 and S2)

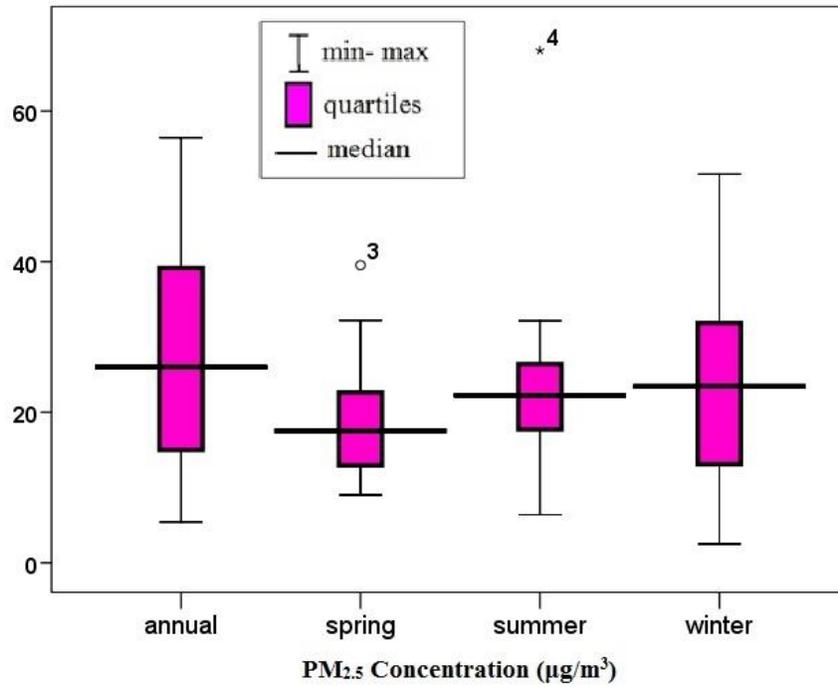


Figure 2. Box Plot of Descriptive Statistics of PM_{2.5} Concentrations in Urmia, Iran (2015-2016)

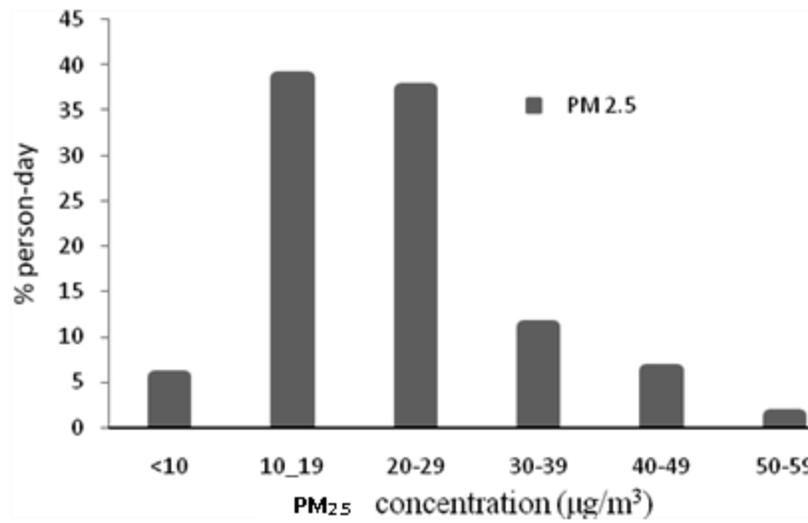


Figure 3. Proportion of Cases Exposed to Various PM_{2.5} Concentrations

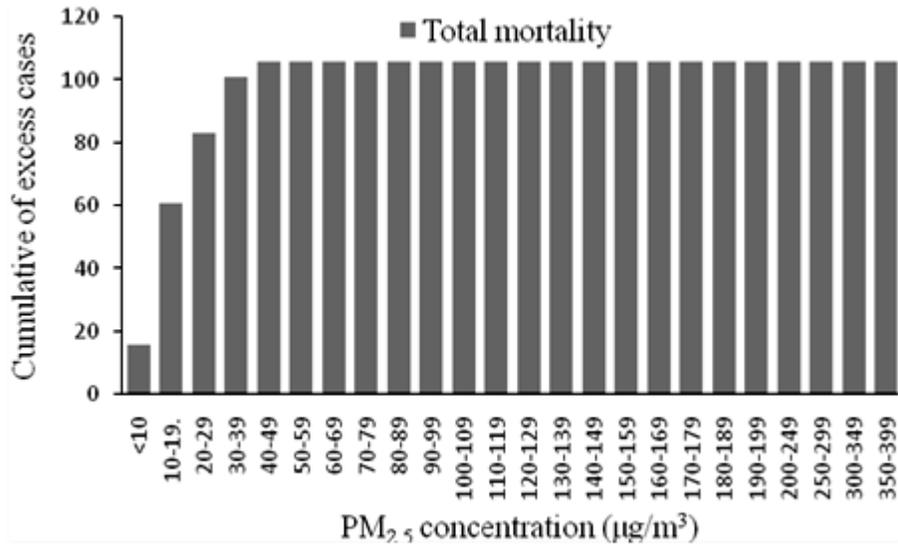


Figure 4. Estimated Cumulative Total Mortality

References

1. Downs SH, Schindler C, Liu L-JS, Keidel D, Bayer-Oglesby L, Brutsche MH, et al. Reduced exposure to PM10 and attenuated age-related decline in lung function. *New England Journal of Medicine*. 2007;357(23):2338-47.
2. 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. *Environmental research*. 2011;111(8):1321-7.
3. Hajizadeh Y, Mokhtari M, Faraji M, Mohammadi A, Nemati S, Ghanbari R, et al. Trends of BTEX in the central urban area of Iran: A preliminary study of photochemical ozone pollution and health risk assessment. *Atmospheric Pollution Research*. 2018;9:220-9.
4. De Meij A, Thunis P, Bessagnet B, Cuvelier C. The sensitivity of the CHIMERE model to emissions reduction scenarios on air quality in Northern Italy. *Atmospheric Environment*. 2009;43(11):1897-907.
5. Naddafi K, Atafar Z, Faraji M, Ghanbarian M, Rezaei S, Ghoskhalil MG, et al. Health Effects of Airborne Particulate Matters (PM10) during Dust Storm and Non-Dust Storm Conditions in Tehran. *Journal of Air Pollution and Health*. 2017;1(4):259-68.
6. Wong C-M, Vichit-Vadakan N, Kan H, Qian Z, Teams P. Public Health and Air Pollution in Asia (PAPA): a multicity study of short-term effects of air pollution on mortality. *Environ Health Perspect*. 2008;116(9):1195-202.
7. Glinianaia SV, Rankin J, Bell R, Pless-Mulloli T, Howel D. Particulate air pollution and fetal health: a systematic review of the epidemiologic evidence. *Epidemiology*. 2004;15(1):36-45.
8. WHO. Particulate matter air pollution: how it harms health. Fact sheet EURO/04/05, Berlin, Copenhagen, Rome. 2005;4:14.
9. Kermani M, Bahrami Asl F, Aghaei M, Arfaeinia H, Karimzadeh S, Shahsavani A. Comparative investigation of air quality (AQI) for six industrial cities of Iran. *Urmia Medical Journal*. 2014;25(9):810-9.
10. Ahmad A, Hashim M, Hashim MN, Ayof MN, Budi AS. The use of remote sensing and GIS to estimate Air Quality Index (AQI) Over Peninsular Malaysia. GIS development. 2006:5pp.
11. Kumar A, Goyal P. Forecasting of daily air quality index in Delhi. *Science of the total environment*. 2011;409(24):5517-23.
12. Mohan M, Kandya A. An analysis of the annual and seasonal trends of air quality index of Delhi. *Environmental monitoring and assessment*. 2007;131(1-3):267-77.
13. Mu H, Otani S, Okamoto M, Yokoyama Y, Tokushima Y, Onishi K, et al. Assessment of Effects of Air Pollution on Daily Outpatient Visits using the Air Quality Index. *Yonago acta medica*. 2014;57(4):133.
14. 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. *Journal of Environmental Health Science and Engineering*. 2012;9(1):28.
15. Tominz R, Mazzoleni B, Daris F. Estimate of potential health benefits of the reduction of air pollution with PM10 in Trieste, Italy. *Epidemiologia e prevenzione*. 2005;29(3-4):149-55.
16. Committee HIO. Health effects of outdoor air pollution in developing countries of Asia: a literature review. Health Effects Institute, Boston, USA. 2004.
17. Ezzati M. Comparative quantification of health risks: sexual and reproductive health: World Health Organization; 2004.
18. Miri M, Aval HE, Ehrampoush MH, Mohammadi A, Toolabi A, Nikonahad A, et al. Human health impact assessment of exposure to particulate matter: an AirQ software modeling. *Environmental Science and Pollution Research*. 2017:1-7.
19. Samet JM, Zeger SL, Dominici F, Curriero F, Coursac I, Dockery DW, et al. The national morbidity, mortality, and air pollution study. Part II: morbidity and mortality from air pollution in the United States *Res Rep Health Eff Inst*. 2000;94(pt 2):5-79.