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Health effects of airborne particulate matter related to traffic in Urmia, NW Iran

***Amir Mohammadi*[1,*], *Maryam Faraji*[2,3], *Saeed Mousavi*[4], *Sepideh Nemati*[5], *Mojtaba Momtaz*[6], *Ali Abdolahnejad*[6], *Mohammad Miri*[7]**

[1] Department of Public Health, Maragheh University of Medical Sciences, Maragheh, Iran
[2] Environmental Health Engineering Research Center, Kerman University of Medical Sciences, Kerman, Iran
[3] Department of Environmental Health, School of Public Health, Kerman University of Medical Sciences, Kerman, Iran
[4] Environmental Research Center of West Azerbaijan, Urmia, Iran
[5] Health and Environment Research Center, Student Research Committee, Tabriz University of Medical Sciences, Tabriz, Iran
[6] Student Research Committee, Department of Environmental Health Engineering, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
[7] Department of Environmental Health Engineering, School of Health, Sabzevar University of Medical Sciences, Sabzevar, Iran

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CORRESPONDING AUTHOR:

mohammadiurm@gmail.com
Tel: (+98 41) 37276363
Fax: (+98 41) 37276363

ABSTRACT:

Introduction: This study aimed to evaluate exposure to PM_{10} related to traffic and drying Lake Urmia and its effects on human health in north-west of Iran.
Materials and methods: Sampling and analysis was done during 2015 to 2016 using AirQ 2.2.3.
Results: The annual mean of PM_{10} concentrations were 106 μg/m^3, which was too higher than 20 μg/m^3 recommended by WHO guideline. The maximum seasonal mean concentration of PM_{10} was observed in winter (138 μg/m^3). Attributable proportion (AP) due to exposure to PM_{10} were estimated 5.487% (95%CI: 3.726-7.185%) of non-accidental mortality cases, 8.011% (95%CI; 4.615-11.174%) of cardiovascular mortality, and 11.174% (95%CI; 4.615-16.215%) of respiratory mortality, for Urmia inhabitants. With every 10 μg/m^3 increase in PM_{10} concentrations, relative risk (RR) for total mortality increased by 0.6%.
Conclusion: The total cases numbers for hospital admission due to cardiovascular and respiratory diseases in central RR were 257 and 666 cases, respectively. Since incineration fossil fuel, the salty dust storms caused by climate change and drying Urmia Lake is natural, therefore, increasing green space and extensive activities such as desertification are need to control this phenomenon that is extremely challenging.

Introduction

Population growth, increasing automobiles and development of urbanization have increased atmospheric pollutants worldwide [1]. The global burden of deaths associated with air pollution has been estimated 865,000 annually by World Health Organization (WHO) [2]. Outdoor and indoor air pollution cause more than 2 million premature deaths each year [3]. Epidemiological studies have demonstrated association between exposure to airborne particulate matter and increased cardiovascular and pulmonary mortality, morbidity from lung cancer, chronic obstructive pulmonary disease (COPD), myocardial infarc-

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tion and increased respiratory and cardiovascular hospital admissions [4, 5]. International agency for research on cancer (IARC) has defined outdoor air pollution as a mixture and particulate matter specifically as carcinogenic to humans (IARC Group 1). Outdoor air pollution is a combination of different pollutants result from natural and man-made sources [6]. Exposure to particulate matter with the aerodynamic diameter of less than 10 µm (PM_{10}) cause adverse effects on the human health due to penetration into the human lung. Immune system reactions, lung irritation, bronchitis, asthma exacerbation, hospitalization due to respiratory and cardiovascular diseases, impaired lung function, chronic bronchitis, cancer, and death can be attributed to PM_{10} [7]. Small fraction of particulate matters ($PM_{2.5}$, with aerodynamic diameter less than 2.5 µm) has more effects on the respiratory tract. $PM_{2.5}$ can block the air passages and damage pulmonary mucosal pathways [8]. Increasing every 10 µg/m^3 in $PM_{2.5}$ concentrations in long term exposure has increased 20 and 49% cardiopulmonary mortality and coronary artery deaths, respectively [2]. In addition to size, other physical and chemical characterizations of PM including mass, surface area, number and composition can affect toxicity and health impacts associated with PM [9]. These characterizations are still not conclusively recognized. However, potential health problems may attribute to the organic matters, metals and other chemically active compounds [10]. Recently, drying parts of Lake Urmia, the second saltiest lake in the world, in northwest of Iran (Asian country in the Middle East), has been resulted to releasing a high extent of particulate matter to the air in the West Azerbaijan province and Urmia city as the center of this province. PM, SO_2 and CO were reported as the most important air pollutants in Urmia city. Dust storm events, inversion, fuel combustion in vehicles and industries have been introduced as the source of mentioned pollutants [11]. Salty dust related to drying some regions of Urmia Lake releases PM with a significant extent of pollutants such as heavy metals and organic matters and other constituents to the ambient air in the West Azerbaijan province. Combination of PM with heavy metals and different constituents related to Urmia Lake and PM from anthropogenic activities has been anticipated to exacerbate health impacts on population of 3,000,000 people in this province [12-14]. AirQ software is a simple, beneficial and user-friendly tool to assess the effects of criteria air pollutants on the exposed population in a specific place and time. This software has been introduced by the WHO European Centre for Environmental Health, Bilthoven Division [2]. Other researchers have applied AirQ to estimate effect of exposure to different pollutants in Iran [2, 3, 7, 15-19] and other places in the world [20-23]. This study aimed to evaluate exposure to PM_{10} related to traffic and drying Lake Urmia and impacts on human health in northwest of Iran according to WHO approach using AirQ. To the best of our knowledge regardless of the significance of salty dust storms on respiratory diseases, this is the first study in term of finding the exposure to PM_{10} originating from drying Lake Urmia and impacts on human health in northwest of Iran.

Materials and methods

Study area

This is an ecological study which period study was from March 2015 to February 2016. The Urmia city have 100 Km^2 area and placed in northwest of Iran in longitude of 45 00′ to 45 07′ E and latitude of 37 29′ to 37 34′N. This region has arid-cold winters, mild springs, hot dry summers and warm autumn's climate. Sampling sites had four stations in deferent points if city which they equipped with online air pollutants detector (Enviro SA) by Urmia department of the environment protection (Fig. 1). Also Urmia Lake and wind rose direction in 2015 year illustrate in Fig. 1.

AirQ 2.2.3

The World heath organization software tool AirQ does calculations that allow estimation of the health impact of exposure to air pollution, including assessment of the reduction in life expectancy. AirQ using life-tables method and based on risk assessment from cohort studies evaluations the effects of long-term exposures. This able used to estimate health effects including total mortality, morbidity and hospital admissions. This software related air quality data in various ranges of concentration with epidemiological parameters such as relative risk (RR), baseline incidence (BI in 10^5 people), and attributable proportion (AP), and show its results as mortality. The AP in this software is calculated according to the following formula:

$$AP = Sum\ \{[RR(c) - 1] \times p(c)\}/Sum\ [RR(c) - 1]$$

Where, RR (c) is the RR of health outcome in the target group, (c) is the population proportion of the target group. By knowing the amount of BI in the target population, we can calculate the attributed value to population contract (IE) by the following formula:

$$IE = BI \times AP$$

Where IE is the quantity of health effect attributable to the exposure, and I is the baseline frequency of the health effect in the target population. Finally, the number of cases attributable to the exposure (NE) can be estimated by the following equation by having the size of population (N) [20].

$$NE = IE \times N$$

RR reflects the rate of a pollutant's impact on the human health by a increas in the pollutant's concentration. RR is found through time-series studies that calculate the concentration increas of air pollutants and their effects on health during a long time period [1].

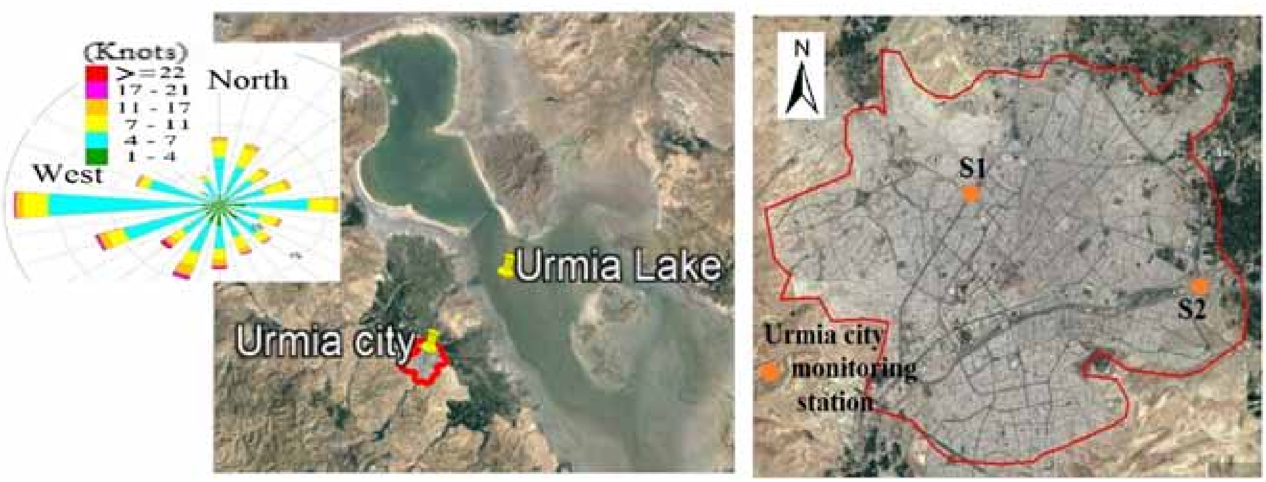

Fig. 1. Study area, wind rose direction, air pollutants monitoring stations

The concentrations of $PM_{2.5}$ and PM_{10} from March 2015 to February 2016 were collected from four online air pollution monitoring stations which are situated near to Bahonar, Shaharchi, Azerbaijan, and Motahhari Squares. These monitoring stations are operated by Urmia Department of Environment. The data were filtered by Excel software according to the WHO recommendations. Then, hot and cold seasonal averages, annual averages, and their maximum, as well as annual 98 percentile for $PM_{2.5}$ and PM_{10}, were extracted. The BI of the total deaths, deaths attributed to cardiovascular and respiratory diseases were estimated using death and diseases data obtained from health Urmia university of medical sciences [24]. In case of needs for other epidemiological parameters which were not available for the city the WHO calculated values were applied. Finally, these data were entered into AirQ software according to the WHO guideline and parameters such as AP, IE, and NE related to PM_{10} and $PM_{2.5}$ were calculated (Table 1).

Results and discussion

This research was done AirQ program to estimate the effects of short term exposure to PM_{10} concentrations on human health for populations living in urban area. The health effects were assess as the increase in all cases, total mortality, cardiovascular mortality, respiratory mortality, hospital admissions due to cardiovascular diseases, and hospital admissions due to respiratory diseases.

Concentration of PM_{10}

The basic descriptive statistic of PM_{10} concentrations were illustrated in Fig. 2. The annual mean of PM_{10} concentrations were 106 μg/m^3, which was too higher than 20 μg/m^3 recommended by WHO as air quality guideline [28]. The maximum concentration value of PM_{10} gained during the winter which theirs averages were 138 μg/m^3, 90 day higher than 20 μg/m^3 and 83 day higher than 50 μg/m^3. The highest monthly mean of PM_{10} concentration with 147 μg/m^3 was recorded in Match. The most probable reasons for this phe-

Table 1. Baseline incidence (BI), relative risk (RR) with 95% confidence intervals (95% CI), estimated attributable proportion (AP) and number of annual excess cases due to short-term exposure to PM_{10} above 10 μg/m^3

Health Endpoints	pollutant	BI*	RR (per 10 μg/m^3)	AP percentage (uncertainty range)[b]	Number of excess cases (uncertainty range)**
Total mortality	PM_{10}	403.82	1.006(1.004-1.008)	5.487(3.726-7.185)	409(278-536)
Cardiovascular Mortality	PM_{10}	178.47	1.009(1.005-1.013)	8.011(4.615-11.174)	105(61-146)
Respiratory Mortality	PM_{10}	27.62	1.013(1.005-1.020)	11.174(4.615-16.215)	23(10-33)
Hospital Admissions Respiratory Disease	PM_{10}	1260	1.008(1.0048-1.0112)	7.185(4.438-9.778)	666(412-907)
Hospital admissions cardiovascular disease	PM_{10}	436	1.009(1.006-1.013)	8.011(5.487-11.174)	257(176-359)

* Crude rate per 100,000 inhabitants per year.

** Obtained using the lower and upper RR values nomena is windy condition in winter with having the height speed from Lake to city (Fig. 1) and also incineration of fossil fuel with vehicles and residential in the study area. In the other seasons average of PM_{10} extracted as rank follow: 101 μg/m^3 in autumn>92 μg/m^3 in spring>90 μg/m^3 in summer. Thus the values of PM_{10} was rarely in warm seasons less than from could seasons which the reason may be related to inversion potential formation in could seasons and too it lead to intensity of air pollution. The responsible pollutant in many of days in winter reported PM [29]. Another studies in Yazd, Tehran, Ilam and Isfahan of Iran shown that the cold season having the highest air pollution and responsible pollutant was PM [8, 10, 15, 19, 30]. The origins of air pollution in these cities mentioned dust storm and traffic which it result similar our finding. Of course in Urmia furthermore dust storm and traffic, drying of Urmia Lake have high potential for salty PM and air pollution.

Health effects of PM_{10}

The inhabitant's exposure to different ranges of PM_{10} in the Urmia city was determinate. But, detailed information about confounders were not easily obtainable. For example, population with sensitive health might be possibly more potential disease to air pollutants, especial particular matters. The days at which populations were exposed to PM_{10} concentrations were illustrated in Fig. 3. According to this figure the highest values exposure to PM_{10} taken within range of 70–79 μg/m^3 during 35 days. Thus, Fig. 3 showed that Urmia population were exposed to PM_{10} concentrations at a higher than WHO recommended. In Table 1 presented the estimate of AirQ model about the effect of PM_{10} on human health for total mortality, cardiovascular mortality, respiratory mortality, hospital admissions for cardiovascular diseases, and hospital admissions due to respiratory diseases. Also the annual BI rate of total mortality in Urmia city was 403.82 per 100,000, the cumulative excess cases for total mortality was 105 in intermediate relative risk situations. The number of excess cases predictable for cardiovascular mortality and respiratory mortality was 105 and 23 incidences, respectively. Privies study reported the main mortality reason in Urmia city was belonged to cardiovascular disease with 44.20 percent of total mortality [24].

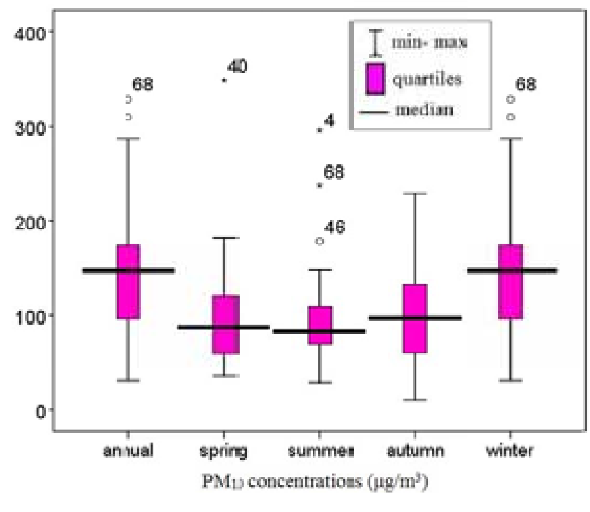

Fig. 2. Box plot graph of descriptive statistic PM_{10} concentrations in Urmia, Iran, in 2015 -2016

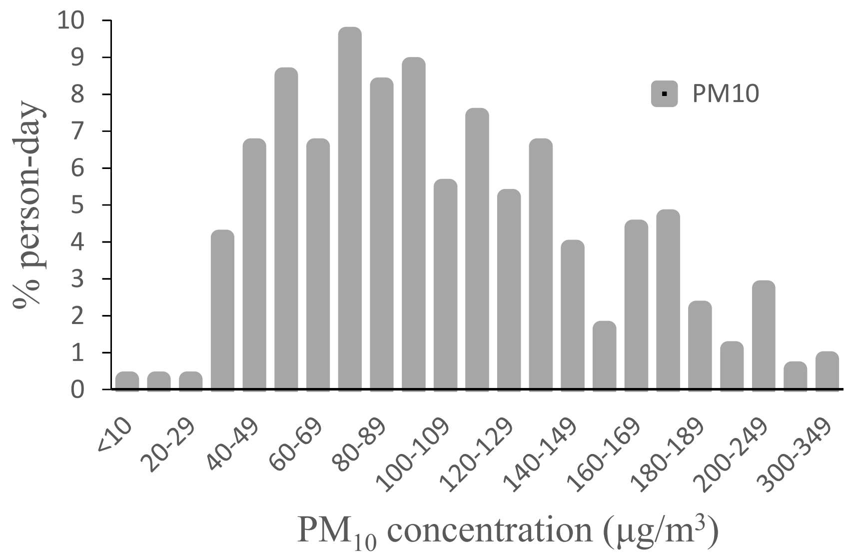

Fig. 3. Proportion of number cases that are exposed to different concentrations of PM_{10}

Fig. 4 show that cases of mortality due to respiratory and cardiovascular diseases in different ranges of PM_{10} concentrations which related to 409 cases (RR=1.006) of total mortality, attributable proportion (AP) 5.487% (95%CI: 3.726-7.185%) of non-accidental mortality cases, 8.011% (95%CI; 4.615-11.174%) of cardiovascular mortality, and 11.174% (95%CI; 4.615-16.215%) of respiratory mortality was predictable using AirQ program for the PM_{10} concentration more than WHO guideline. With every 10 µg/m^3 rise in PM_{10} concentrations, relative risk for total mortality augmented by 0.6%.

On based of Fig. 4, after 59 µg/m^3, all the mortality was increased very fast. For cardiovascular mortality, with every 10 µg/m^3 increase in PM_{10}, RR increased by 0.9%, and for respiratory mortality, 1.3% increase was observed. More than 92% of short-term effects occurred at the time when PM_{10} concentration was less than 179 µg/m^3. In Fig. 6 given the cumulative cases of different health effects attributed to PM_{10} concentrations which show the number of hospital admissions (HA) due to cardiovascular diseases and respiratory diseases in different ranges of PM_{10} concentration (RR of 1.009 and 1.008, respectively) As this Figure each 10 µg/m^3 increase in PM_{10} concentrations has lead 0.8 % increase in RR for HA due to respiratory diseases and cardiovascular diseases.

The total cases numbers for HA due to cardiovascular and respiratory diseases in relative average risk were 257 and 666 persons, respectively. More than 66% of the persons were associated with the PM_{10} concentrations of less than 119 µg/m^3.

In a study in Tehran, exposure to PM_{10} concentrations of more than 20 µg/m^3 was reported as major factor for 4.6% of total non-accidental mortality [30]. In another study in Mashad city with 82.9 µg/m^3 value of annual mean PM_{10} reported that 4.24% (CI95%; 2.87–5.58) of non-accidental total mortality, 6.23%(CI95%; 3.56–8.7) of cardiovascular mortality, and 8.76% (CI85%; 3.56–12.88) of respiratory mortality are associated to PM_{10} concentration [3].

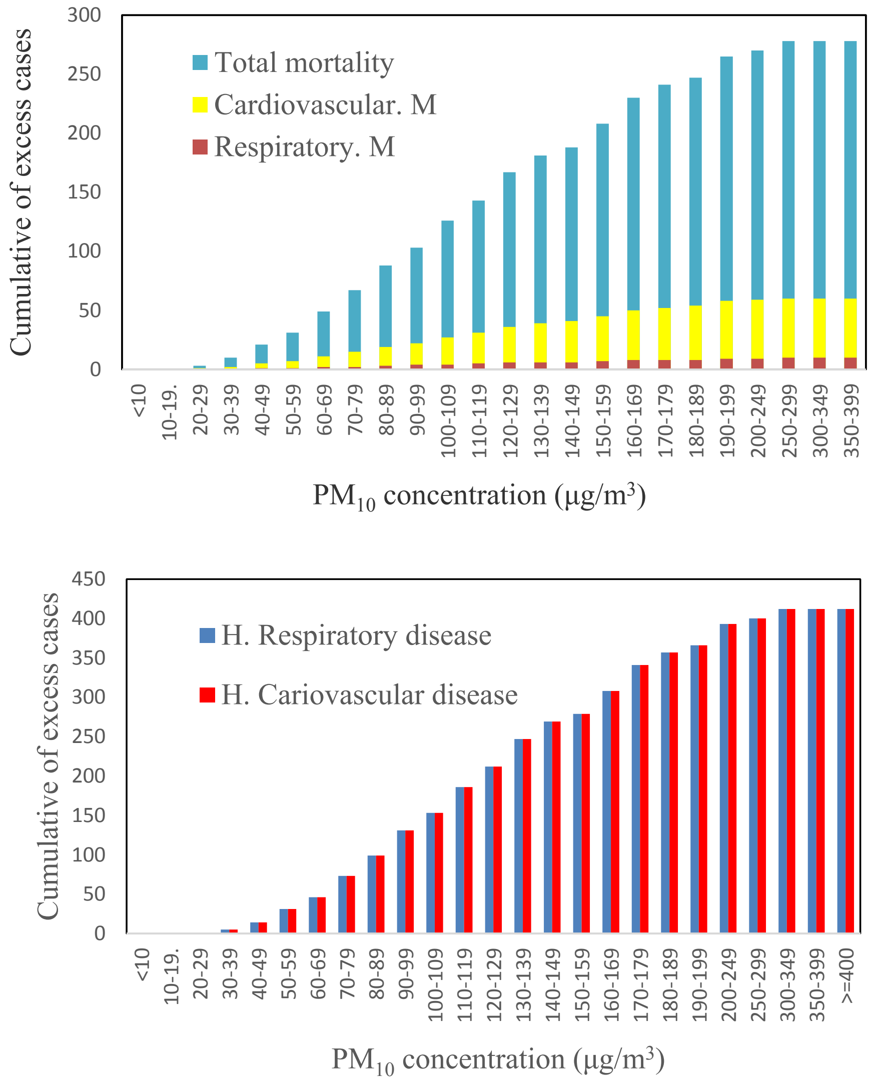

Fig. 4. Estimated cumulative number of total mortality, cardiovascular, and respiratory mortality cases associated PM_{10} based on central RR

In other study in urban and industrial area in Tabriz described the total mortality number related to TSP, $PM_{2.5}$, and PM_{10} values obtained 327, 360, and 363 µg/m^3, respectively [31]. In two urban area in Northern Italy reported that $PM_{2.5}$ had the main factor for health impact on inhabitants living in two small cities. The exposure to PM_{10} in hort term with the concentration of more than 20 µg/m^3 in Trieste, a city in the north-east of Italy with about 200,000 population, 52, 28, and 6 cases were assessed for total mortality, cardiovascular mortality, and respiratory mortality, respectively. They resulted that 2.5% of respiratory mortality and 1.8% of cardiovascular cases were associated to the values of higher than 20 µg/m^3 [32] The observations of these studies based on excess cases are consistence to that of our study in Urmia. Although further incineration fossil fuel, salty dust from Urmia Lake is sources of PM_{10}. Total mortality in Milan from Italy (1,308,000 population), predicted by AirQ model was 677 cases attributable to PM_{10} [33].

In totally, a comparison our result with the other researches in Trieste and Tehran could observed that the high rate of mortality is associated to higher mean values of PM_{10} or the number of days with high PM_{10} concentration in the study area due to fuel incineration and also dust from drying Urmia Lake as emerging natural tragedy which it could be treated for population living in some parts of Iran, Turkey, Armenia and Azerbaijan [12]. Furthermore in coming years, it estimated more than 10 million people will be expose to this salty PM which may be lead to several skin, eye and respiratory diseases.

Also in similar studies in 29 European cities, numerous Asian countries, and 20 American cities, it has been reported that short-term harmful health effects of exposure to PM_{10} in the developing and developed countries are the same, and mortality rate was heightened by 0.72% when daily PM_{10} was augmented by 10 μg/m^3 [2, 34-36].

Conclusion

The finding of this study show that emission pollutants form traffic, incineration of fuel in residential and salty dust from drying of Urmia Lake are main sources for air pollution with PM_{10}. Thus increasing green space preventive of Lake drying are very emergency.

In this study, the AirQ along with assessment of central point of the relative risk (confidence interval 95%) were applied to consider the health effects of PM_{10} on Urmia inhabitants in 2015. Results showed that the effect of PM_{10} on total mortality related to respiratory and cardiovascular disease with 409 cases was more than from many cities in Iran. Also the main mortality reason in Urmia city was belonged to cardiovascular disease with 44.20 percent of total mortality.

Unfortunately the concentration of PM_{10} was over the concentration than the WHO recommended, 20 in 318 days. Since incineration fossil fuel, the salty dust storms caused by climate change and drying Urmia Lake is natural, therefore, extensive activities such as desertification are need to control this phenomenon that is extremely challenging. It is clear that such activities are long-term and, therefore, some intermediate and short-term strategies should be carry out to overcome this tragedy.

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Data in this study was taken from Urmia Department of Environment**.**

Competing interests

This paper has no competing interests

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Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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