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Mortality and morbidity due to exposure to ambient particulate matter

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ABSTRACT

The aim of this study was to investigate spatial variation and health risk of the exposure to $PM_{2.5}$ (particulate matter with a diameter of 2.5 µm or less) and PM_{10} (particulate matter with a diameter of 10 µm or less) in Sabzevar, Iran. $PM_{2.5}$ and PM_{10} were measured during three campaigns from April to November 2017, in 26 sampling points. Spatial analysis was performed using kriging and autocorrelations (Moran's index) model in Arc GIS software. Relationship between exposure to the $PM_{2.5}$ and PM_{10} and their health impacts were investigated by AirQ 2.2.3 software. The mean concentrations (and standard deviation) of PM $_{2.5}$ and PM_{10} over the entire study period were 32.54 (37.28) and 42.61 (47.76) µg/m^3, respectively, which were higher than the guideline of World Health Organization. According to the spatial analysis, the maximum concentrations of $PM_{2.5}$ and PM_{10} were around the main highway (beltway) which placed all over the south of Sabzevar. According to the Moran's index, the emission patterns for $PM_{2.5}$ (Z-score = 2.53; P-value = 0.011) and PM_{10} (Z-score = 2.82; P-value = 0.004) were clustered. The attributable percentage (AP) of total mortality related to $PM_{2.5}$ and PM_{10} were 3.544% (95% confidence interval (CI): 2.623–4.447%) and 2.055% (95% CI: 1.379–2.721%) per increasing each 10 µg/m^3 of these pollutants, respectively. According to observed results, it is suggested that the beltway and other pollution sources, such as industries, should be placed at a greater distance from the city, to reduce PM amounts in residential areas.

1. Introduction

Different air pollutants in the ambient air can affect human health and the natural environments (Miri et al., 2016e; Alahabadi et al., 2017). The main concern for health effect of exposure to atmospheric air pollutants is related to the high risk of exposure due to low concentrations of these pollutants. Every year, more than two million deaths are occurred as a result of exposure to the air pollution through damage to the respiratory system all over the world (Kim et al., 2015). PMs are the most hazardous portion of air pollutant particulate (Shah et al., 2013). PMs are a heterogeneous mixture of different pollutants in solid or liquid phases with different sizes and chemical compositions (WHO, 2013). Heterogeneous chemical constituents such as heavy metals, polycyclic aromatic hydrocarbons (PAHs) and biological compound (spores, cell fragments) on core mineral nucleolus of PMs exacerbate their toxicity (WHO, 2013). Exposure to PMs are associated with heart and lung diseases, asthma attacks, decreased lung function, stroke and increased respiratory symptoms (Burnett et al., 2014; Baldacci et al., 2015; Rice et al., 2015; Desikan et al., 2016). The PMs can be emitted into the air directly from natural or anthropogenic sources or formed in the air during photochemical reactions (Burnett et al., 2014). Many anthropogenic sources can cause emissions of PMs into the atmosphere. Traffic related air pollutants (TRAPs) is the most important anthropogenic source of PMs, followed by industrial activity and solid fuel combustion (Srimuruganandam and Nagendra, 2012; Miri et al., 2016a). Dust storms, volcanoes and forest fire are some examples of natural sources of PMs, which also impose health risk on the exposed population (Lenschow et al., 2001).

Different methods and models are used to evaluate the effect of air pollution on human health. Most of available methods integrate air

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pollution data with epidemiological risk estimates (Krzyzanowski et al., 2002). Meanwhile, AirQ2.2.3 software has been considered as one of the most reliable and accurate tool for estimating the health effects of air pollutants, in which health impacts are estimated according to the combination of information on population exposure-response relationships (Conti et al., 2017). This software was developed by European center of world health organization (WHO) (Organization, 2001). This software has been widely used to assess the health effects of exposing to the air pollutants (Fattore et al., 2011; Naddafi et al., 2012; Miri et al., 2016b, 2017; Nikoonahad et al., 2017; Asl et al., 2018). It has been reported that this model is useful tool to evaluate the effect of air pollutants on human health.

In present study spatial autocorrelation (Moran's index) and Kriging interpolation method were used to spatial analysis of $PM_{2.5}$ and PM_{10} pollutants. Finally, the health risk assessment of exposure to these pollutants were evaluated using AirQ 2.2.3 software.

2. Material and methods

2.1. Study area

Sabzevar, a city in Khorasan-Razavi province with a population of 240,000 and an area of 23 km^2, is located in the North-East of Iran. Sabzevar is in 57° 43' longitude, 36° 12' latitude, and altitude of 950 m above the sea level (Fig. 1). The average humidity is 43%, the annual average of rainfall is 330 mm, and the wind direction is generally east to west. The annual average of temperature in Sabzevar is 16 C° (minimum and maximum temperature are −22 C° and 45 C°, respectively). The most crowded highway in Iran passed from the southern part of Sabzevar. Therefore, this city presumably undergoes a noticeable release of air pollutants.

2.1.1. Sampling and analysis

The $PM_{2.5}$ and PM_{10} measurement were conducted at 26 monitoring stations of different microenvironments of studied area (different land use and traffic volume) according to the United State Environmental Protection Agency (USEPA) standards at a distance of 20 m from the street and other sources of pollution at an elevation of 15 m above the ground level (Fig. 1). Sampling was conducted during three campaigns in spring (April to June 2017), summer (July to September 2017) and autumn (September to November 2017). The winter was missed due to some technical problems. Finally, the pollutants were measured at 159 days of 2017. As the main aim of this research was the health risk assessment of PMs related to the traffic, the stormy days were excluded from analysis and sampling. $PM_{2.5}$ and PM_{10} were measured by the real-time monitoring device (HAZ-DUST EPAM 5000, USA). In This device "near-forward light scattering" of an infrared radiation combined with traditional gravimetric method which can provide continuous measurements of PM in an ambient air. This principle utilizes an infrared light source positioned at a 90-degree angle from a photodetector. As the airborne particles enter the infrared beam, they scatter the light, so the amount of light received by the photodetector is directly proportional to the aerosol concentration. Some benefit of this device are, the capability of responding quickly and recording information of particulate matters, separating particulates size, with 47 mm filters to perform weight studies, according to the USEPA and TEOM measurement methods (Traviss et al., 2010; Bu-Olayan and Thomas, 2012). The sampled air is filtered through an optical sensor, and then through a 7 mm weighted filter that installed exactly just after the optimal sensor (Costa and Guarino, 2009). To measure $PM_{2.5}$ and PM_{10}, the specific selector for every pollutant were placed on the instrument. Gravimetric technique was also employed one time for every season (three times) as a correction factor for the collected data of continuously monitoring. Polytetrafluoroethylene (PTFE) membrane filters with 47 mm of diameter, SKC, were used for this purpose. The PTFE filters were weighted by a microbalance (0.00001 g) in laboratory with controlled humidity before and after PM sampling

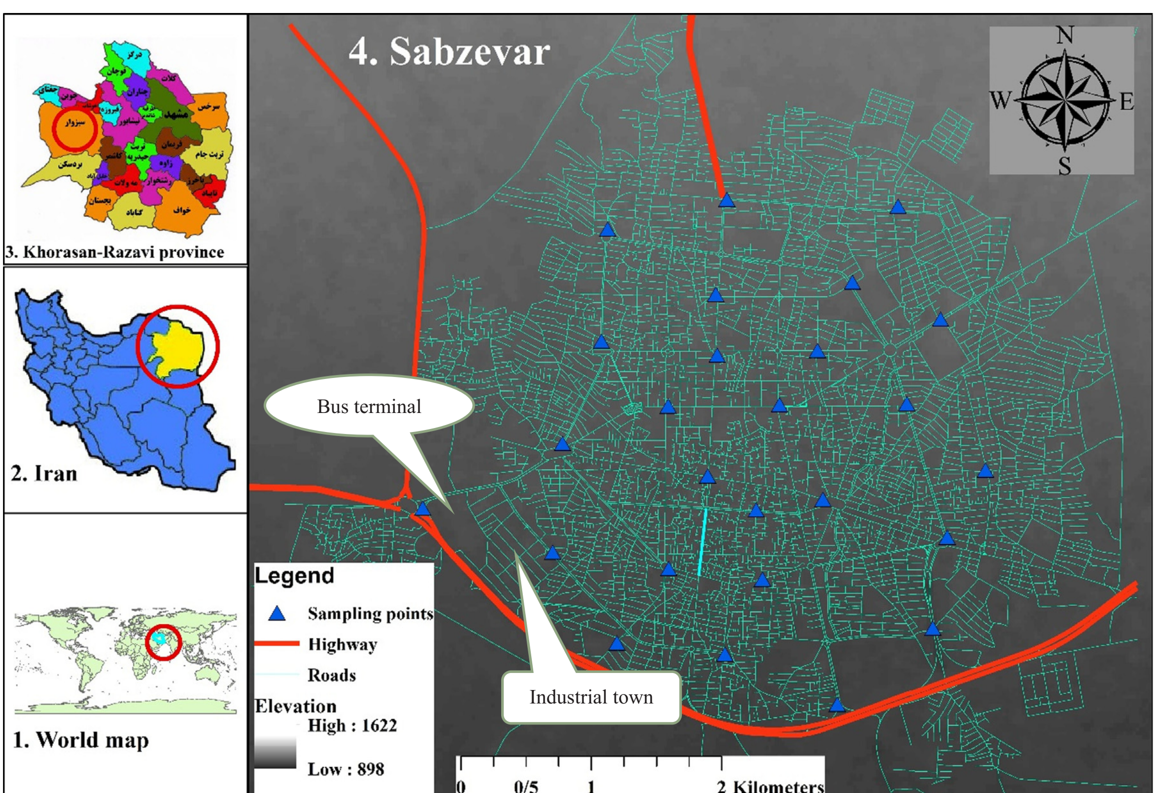

Fig. 1. Study area and sampling locations.