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The effects of emission sources and meteorological factors on sulphur dioxide concentration of Great Isfahan, Iran

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HIGHLIGHTS

- The air pollution problem in Isfahan has not enough investigated before.
- Industries and power generation plant around the city have considerable effects on SO_2 concentration variation.
- Long term wind pattern of Isfahan is another important reason of high SO_2 concentration.
- Meteorological factors have considerable effect on SO_2 concentration variation.
- Temperature has largest effect on the SO_2 concentration in Isfahan among the other factors.

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ABSTRACT

The great Isfahan has experienced an almost fast industrialization during the last years. The different factories and industries near that, cause one of the important environmental problems, air pollution, which has not enough investigated before in this area. The hourly, diurnal and seasonal variations of SO_2 concentration as one of the most dangerous air pollutants, are studied to clarify the rule of industry on the air pollution problem. The data had been measured continuously from April 2006 to March 2007 at two stations, Lale & Azadi. The air pollution concentrations in an urban area have a close relationship with meteorological factors. Hence, the variation of SO_2 concentration is analysed respect to the meteorological factors such as temperature, relative humidity, wind speed, solar radiation, and pressure. Moreover, the studied air pollutant is also statistically investigated through correlation analysis and stepwise multiple linear regression equation.

It was observed that electric power plant near the Isfahan, Montazeri, has significant effects on the SO_2 concentration in the east and north of Isfahan. Long-term pattern of Isfahan winds which is westerly during the winter and spring, and easterly during the summer and autumn, was recognized as one of another important factors influenced the SO_2 concentration variations. It is also achieved that meteorological factors have considerable contribution, $R^2 = 52\%$, on the SO_2 concentration variation and temperature has largest effect among the others.

1. Introduction

Air pollution and its dangerous impacts on the human health is one of the major problems of humanity caused mainly by industrialization and new styles of human life (Henschel et al., 2012; Melkonyan and Kuttler, 2012; Banerjee et al., 2011; Rodriguez et al., 2010). Population growth during the last century increased the number of automobiles in one hand and expand the industrial plants around the cities in the other hand. Both of them are the important sources introduced a huge amount of air pollutants to the lower atmosphere. Moreover, increasing the energy demand and further developing the power generation plants using fossil fuels is also another origin which emitted dangerous pollutants such as sulphuric dioxide (SO_2) in the atmosphere (Zhao et al., 2009). SO_2 concentration in the lower atmosphere has more interested among the other air pollutants during the last years (Nazari et al., 2012; Iqbal et al., 2014). SO_2 is known as one of the indicators of air quality (Jeong and Park, 2013). The main source of SO_2 in the urban areas is burning the fossil fuels such as coal and heavy fuel oil (73%), other industrial facilities (20%), and natural sources (less than 7%) (Nazari et al., 2012). SO_2 among the other air pollutants has worse effects on the human health and environment

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(Luvsan et al., 2012). SO_2 can react with the other atmospheric chemical compounds to form small particles. These particles penetrate deeply into the respiratory system and cause respiratory disease and sometimes respiratory cancers (EPA, 2011). On the other hand, SO_2 can form an acidic solution in water by certain reactions given by (Akabueze et al., 2012):

$$SO_2 + \frac{1}{2}O_2 \rightarrow SO_3 \quad (1)$$

$$SO_3 + H_2O \rightarrow H_2SO_4 \quad (2)$$

Hence, SO_2 is a major component of acid rain which damage a lot the environment. The concentration of SO_2 in an urban area can be consider as a symbol of the effects of industrialization on the environment (Zhao et al., 2009; Luvsan et al., 2012). Thus, study of SO_2 level in an area, offers important opportunity for tracing environmental destruction caused by industrialization (Flemming et al., 2005). However, there are many effective factors on the SO_2 concentration of a region which were studied by many previous investigators (Chu et al., 2008; Iqbal et al., 2014). It was shown that meteorological factors affect the SO_2 concentration depend on the climate conditions of the study area (Khedairia and Khadir, 2012; Henschel et al., 2014; Ray and Kim, 2014). Although there are many studies in different place of world which investigated the SO_2 concentration variation and its effective factors, but there are still some new places experienced an almost fast industrialization recently and was not considered, up to now. The great Isfahan, shown in Fig. 1, is one of those new places.

The historical city of Isfahan, in the center of middle east was recognized as the second most polluted city of Iran, after Tehran. Nowadays, the air pollution has became one of major problems of this city, but there is no any studies which were investigated the SO_2 concentration level and its effective factors in this area. On the other hand, a lot of industrial factories near the Isfahan with distance less than 50 km obtain an almost unique opportunity to study the effect of industry on the environment.

The purpose of this paper is to study SO_2 concentration pattern and the effects of industrial emission sources, meteorological factors, climate and geographic conditions on the SO_2 concentration variation during a year in the great Isfahan. For this, the characteristics of climate and weather condition of Isfahan are illustrated firstly, then the effective factors on SO_2 concentration level is introduced and discussed.

2. Materials and methods

2.1. Features of Isfahan

The historical city of Isfahan, located in the center of the Iran plateau surrounded by the largest and most arid desert land of Iran. The outstanding features of Isfahan are little rainfall, average less than 122.7 mm, and fast winds. Isfahan is located in 33.38°N, 51.39°W, and elevation 1550–1650 m, with more than 2.1 million population. There are more than a million automotive and heavy-duty vehicles using diesels, gasoline, and natural gas in Isfahan. This city is known as the largest industrialized region in Iran, where there are many industrial states, steel companies, and etc. in its suburb with distances less than 50 km indicated in Fig. 2. There is also one of the biggest electric power plant of Iran, Montazeri, in the suburb of Isfahan, which generate around 10.735 GWh electric energy during the 2007 (Nazari et al., 2012).

Montazeri plant is a steam power plant which is recently use natural gas. However, Montazeri use heavy oil during the cold days due to increasing the domestic heating (Nazari et al., 2012). Regarding the fact that Irans steam power plants do not utilize SO_2 reduction system, a considerable amount of this pollutants is produced in those plants which lead to increase the SO_2 concentration level (Nazari et al., 2012). On the other hand, there is a sugar factory in the east of Isfahan city indicated in Fig. 2(a) by arrow *E*, which can be consider as another source of air pollutants.

2.2. Measurement stations

The hourly SO_2 concentration data is attained from April 2006 to March 2007 by the Environmental Department of Isfahan. The sampling sites which are located in the Lale and Azadi squares, indicated in Fig. 2, are respectively the northern and southern gates of the town, and named Lale and Azadi station hereinafter. It should be noted that those squares are characterized by a high traffic density as well as the population concentrated. The meteorological factors, *i.e.* atmospheric pressure, *P* (hpa), air temperature, *T* (°C),

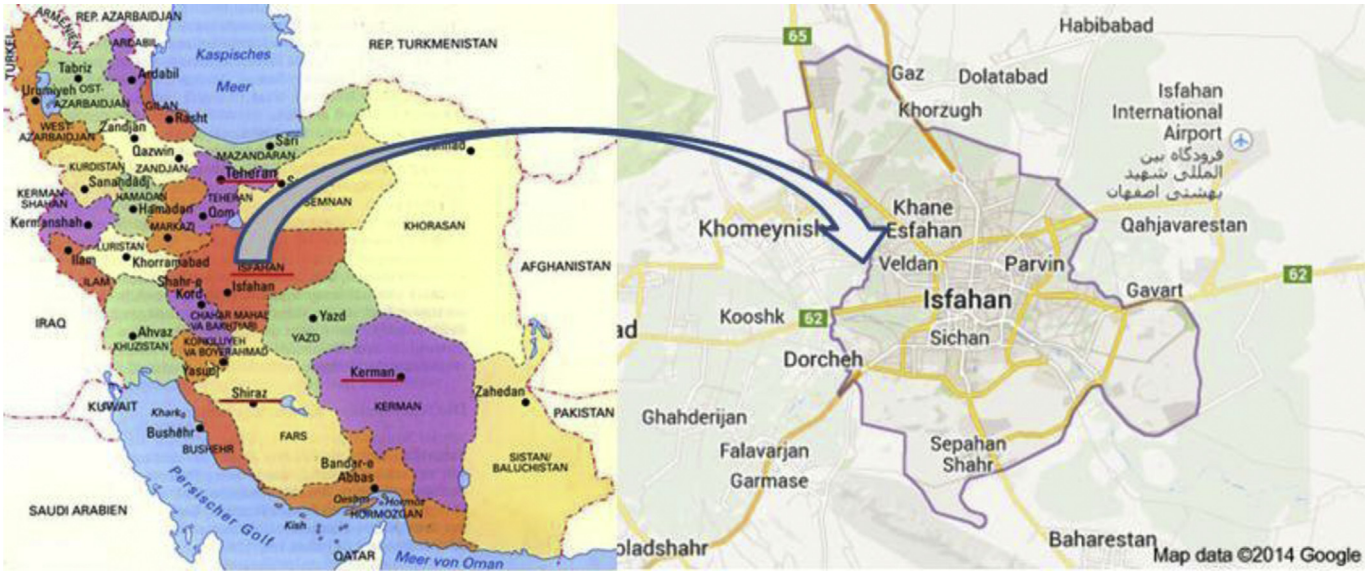

Fig. 1. Map of Iran including the great Isfahan.