original article

Assessment of suspended particulate matters and their heavy metal content in the ambient air of Mobarakeh city, Isfahan, Iran

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ABSTRACT

Aim: This study was carried out to investigate the quality of Mobarakeh ambient air in terms of suspended particles and heavy metals.

Material and Methods: The current study was carried out in Mobarakeh city, Isfahan, Iran. Air sampling was performed in three sites for a 1-year period (in 2007). Measurement of total suspended particles (TSP) and heavy metals was achieved using high volume air sampler with fiberglass filter. The concentration of heavy metals, including Pb, Ni, Zn, Fe, and Cu was measured by atomic absorption spectrometry.

Results: The average concentration of TSP was maximum and minimum in autumn and spring, respectively. In addition, the average of annual TSP concentration (124.61 mg/L) was more than World Health Organization (WHO) and US Environmental Protection Agency standard values. The analysis of filtered suspended particles for heavy metals showed the highest concentration for Iron. The average annual concentration of Nickel was also more than its proposed standard by WHO.

Conclusion: This study showed that ambient air of Mobarakeh city is polluted by TSP. The high concentration of Fe and Ni in this area may be attributed to the nearby industrial emissions. Therefore, in industrial areas, efforts should be taken to control the atmospheric pollution in order to protect humans from hazardous health effects of these potentially toxic pollutants.

Key words: Air pollution, heavy metals, Mobarakeh city, TSP

INTRODUCTION

Clean air is considered to be a basic requirement for human health and other living beings.[1] Air quality in developing countries has deteriorated because of the population growth, increase in the number of vehicle and industries, and also due to lack of implementation of stringent emission standards.[2,3] Air pollution in these countries is one of the main reasons of concern from public-health and environmental safety point

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of view.[4] Air pollution means the presence of one or some pollutants (or a combination of them) in outdoor or indoor atmosphere in the values that damage human, plant, or animal health or properties or disturbs a comfortable life.[5] In spite of the cleaner technologies in industry, energy production, and transport, air pollution remained a major health risk. So tighter emission controls are being enforced by many governments. The pulmonary deposition and adsorption of inhaled chemicals could lead to adverse effects on human health. Public health can also be indirectly affected by deposition of air pollutants in environmental media and uptake by plants and animals, resulting in chemicals entering the food chain or presenting in drinking water. Furthermore, the direct effects of air pollutants on plants, animals, and soil can influence the structure and function of ecosystems and thus affecting the quality of life.[1] Air pollution is related to some gases (nitrogen oxides, sulfur oxides, carbon oxides, and others) and particulate pollutants (organic and nonorganic).[6] Total suspended particles (TSP) comprise all solid and liquid matters transported by air.[2,3] Suspended particles are emitted into the atmosphere from various natural and anthropogenic sources, including transportation, industrial and agricultural activities, and biosolid combustion.[7,8] Suspended particles are the main cause of cancer and respiratory problems. It is proved that high concentrations of these particles cause premature deaths.[2] Numerous studies reported that long exposure to high concentration of suspended particles could lead to increasing number of hospital admissions, respiratory diseases, cancer hazard, and death due to cardiovascular diseases.[9] The effects of particulates matters (PMs) is including effect on visibility and also degradation and climate change.[10] PMs play an important role in the formation of acid rain, the amount of sunlight reaching the ground and variety of environmental processes.[11] Suspended particles can transfer hazardous or toxic pollutants such as heavy metals, cyclic aromatic hydrocarbons, and also organic and elemental carbon.[9] Heavy metals are nonorganic particulate pollutants that are emitted into the atmosphere via natural and anthropogenic sources such as extraction, metal melting, garbage burning, fossil fuels combustion, rocks erosion, industrial activities, mining, and so on.[6,12,13] Heavy toxic metals are found less in earth crust but anthropogenic activities emit a considerable amount of these elements to the atmosphere. Harmful effects of heavy metals are proved well in airborne dust.[14] They are harmful for humans and animals and can biologically accumulate in food chain.[15] Various studies in social and work environments proved that accumulation of heavy metals in the body through breasting or swallow could lead to cancer, nervous, immunity, and heart problems, which increase mortality rate or diseases among people.[6] Also, it is proved that heavy metals, TSP, and PM less than 10 micron (PM_{10}) can be toxic for live creatures in determined values.[13] Urban populations can be exposed to metals through suspended particles.[4] As toxic effects of heavy metals are well identified, concentration determination of these elements in air particles is important in air pollution studies.[6] Considering the location of Mobarakeh city and big and small industries in the proximity of the city, the air of this city is exposed to various pollutants of the industries. Thus, the purpose of the present study was to investigate the air pollution of Mobarakeh city in terms of suspended particles and heavy metals.

MATERIALS AND METHODS

Study area

The current study was carried out in Mobarakeh city in Isfahan, Iran. Mobarakeh city is located 65 km southwest of Isfahan in an area of 1018 km^2 in the longitude of 51°48′ and 51°13′ and northern latitude of 32°28′ and 32°3′. Several industries are located nearby the city, which could emit various kinds of air pollutants into the atmosphere. The climate of this city is cool and dry with dry summers. The maximum temperature of this city is 36°C-39°C in summer and the minimum is 7°C-9°C in winter. Average annual rainfall of Mobarakeh city is 150 mm.

Sampling location

Air sampling was performed in three sites, including site 1 (Gas Co., in the suburb), site 2 (Hafez Sharqist., under the influence of population), and site 3 (Health Center of Sina, under the influence of population and traffic) [Figure 1].

Measurement of suspended particles

The samples were collected using high-volume air sampler with fiberglass filter. The sampling collection in each site was carried out three times in each month. The sampling time was 24 h for 36 days. The particles were measured based on the difference of primary weight of filter and weight of collected particles. To compare this concentration in different geographical zones and various environmental conditions, the volume of air should be converted into equal volume at standard condition (P =1013 mbar, T = 298°K = 25°C).

Heavy metals measurement

A definite section of the filter on which suspended particles were accumulated by volume devices was cut and digested in 3 M nitric acid. The concentration of metals including Pb, Ni, Zn, Fe, and Cu was measured by atomic absorption spectrometry (model 2380, PerkinElmer Co.).

Meteorological parameters

Climatic parameters including temperature, relative humidity, rainfall, and wind velocity data were obtained from the meteorology center of Isfahan province.

Statistical analysis

Statistical analysis was performed using SPSS ver.18.0. The data analysis of the relationship between suspended particles and measured metals with each other and climatic parameters were performed by Pearson's correlation and Duncan test. A *P* value of < 0.05 was considered significant.

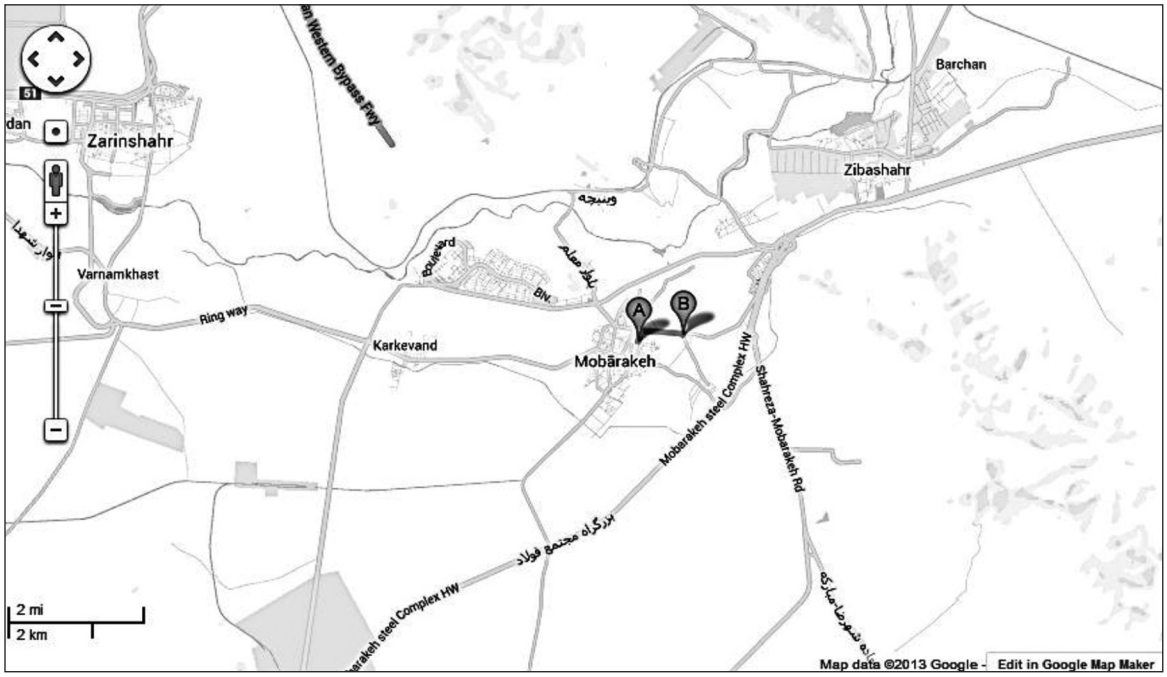

Figure 1: The location of sampling sites in Mobarakeh city, Iran

RESULTS

The average of TSP concentration and heavy metals in sampling sites are shown in Table 1. Figure 2 shows the weight ratio of heavy metals in TSP. Fe with 19.32 mg/g had the maximum weight ratio and lead with 0.16 mg/g had the minimum weight ratio of the particles. Table 2 shows the values of relative humidity, temperature, wind velocity, and rainfall in Mobarakeh city in 2007. Figures 3 and 4 demonstrate the concentration of the metals and TSP measured during various months. The annual average of TSP and heavy metals and their comparison with World Health Organization (WHO) and US Environmental Protection Agency (USEPA) standard are shown in Table 3.

DISCUSSION

As a result of rapid urbanization and increased human activities, the air quality has been deteriorated significantly in most of the cities. Heavy metals are harmful for health because their accumulation in the body can lead to various problems. So, it is necessary to investigate the air quality in urban regions to identify the existing heavy metal compounds in suspended particles.[6] In the present study, the concentration of some heavy metals in TSPs was measured. These heavy metals were collected in three sites in Mobarakeh city, Iran. The average concentration of TSP was higher in autumn and lower in spring [Figure 3]. In addition, the annual average of total suspended particles concentration was higher in comparison to the standard values of WHO and USEPA [Table 3]. This result was consistent with the previous study conducted by Awan *et al* and Shah *et al*. In the study by Shah *et al*., which was carried out in urban atmosphere of Islamabad (Pakistan), the 24-h TSP levels were found to be significantly higher than WHO and USEPA standard values.[8,11] The analysis of suspended particles for heavy metals showed the presence of Pb, Ni, Zn, Fe, and Cu metals in various concentrations [Table 1]. Statistical analysis showed that there is no significant difference between the sampling sites in terms of TSP value [Table 1]. As shown in Figure 2, weight ratio of heavy metals in TSP was different. In this regard, Fe with 19.32 mg/g and lead with 0.16 mg/g were shown the maximum and minimum weight ratio of the particles, respectively. The order of average concentration of heavy metals in the air was Fe>Zn>Cu>Ni>Pb, respectively. This result was consistent with the study by Salam *et al*. They investigated aerosol chemical characteristics of a mega-city in Southeast Asia (Dhaka, Bangladesh). According to the their results, the total iron levels at the Dhaka urban sites varied from 20.4-29.1 μg/m^3.[16] Fe is the most abundant metal in nature and it is used widely.[6] One of the reasons of high concentration of Fe in the city may be due to the passing of Fe powder train in the city. Zn occurs naturally in soil and ambient air particulate matter. In industrial regions, Zn-containing particles have been released through metal melting and extraction factories, which use zinc for protective coating of iron, steel, and alloy.[6,11] Zn concentration was different in sampling sites and this difference was high between sites 1 and 3. This difference was found to be significant statistically ($P < 0.001$). The Cu is the third metal, which is being used in the industry after Fe and Al.[6] In the present study order of its concentration also was the third metal in collected particles. The emissions of the industries located in the suburb of the Mobarakeh city and using Cu in these industries could be linked to the presence of Cu in the

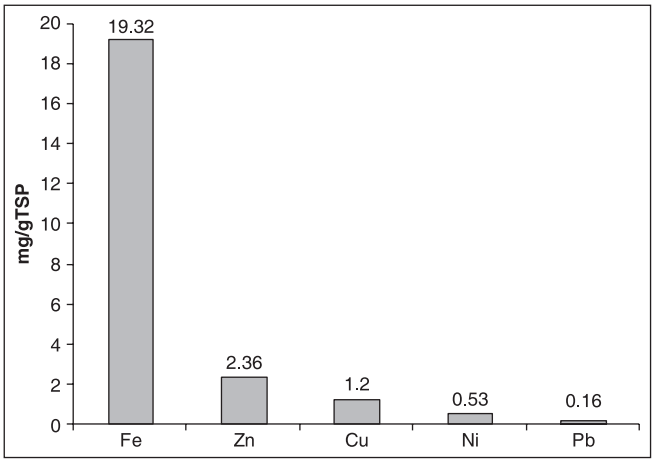

Figure 2: Weight ratio of heavy metals in total suspended particles.

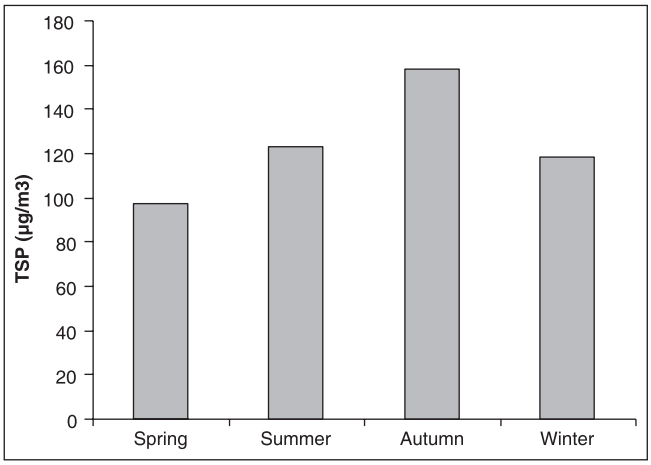

Figure 3: Seasonal variation of total suspended particles concentration.

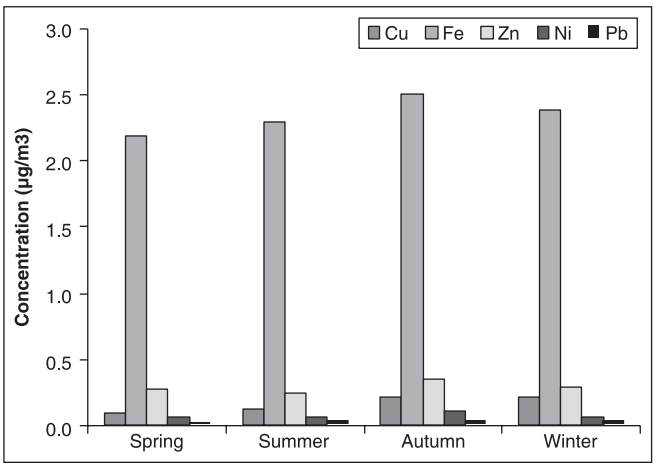

Figure 4: Seasonal variation of the heavy metal concentration.

air.[6] Ni of the atmosphere is due to the combustion of fossil fuels, particularly oil.[14] As it is shown in Table 3, the average annual Ni was more than the WHO standard values.[17] Pb

Table 1: The average concentration of the TSP and heavy metals in sampling sites

Sampling location	(µg/m³) Concentration					
	TSP	Fe	Zn	Cu	Ni	Pb
Site 1	119.24	2.16	0.24	0.11	0.05	0.02
Site 2	125.88	2.3	0.27	0.16	0.07	0.02
Site 3	128.69	2.53	0.34	0.19	0.08	0.03
Total	124.61	2.33	0.28	0.15	0.07	0.02

TSP, total suspended particles

Table 2: Maximum, minimum, and average of relative humidity, temperature, wind velocity, and rainfall in Mobarakeh city during sampling

Month	Temperature (°C)	Relative humidity (%)	Wind velocity (m/s)	Rainfall (mm)
Maximum	36.8	61.7	3.9	9.4
Minimum	-6.8	22.7	1.93	0
Average	15.5	38.6	2.8	1.3

Table 3: Annual average of TSP (µg/m³), heavy metals (ng/m³), and their standard values

	TSP	Fe	Zn	Cu	Ni	Pb
Minimum	83.8	1600	130	20	20	3.8
Maximum	198.5	3800	510	390	180	38
Average	124.61	2330	280	150	70	20
Standard deviation	36.48	440	90	90	40	10
WHO	80	—	—	—	20	500
USEPA	60	—	—	—	—	1500

TSP, total suspended particles, WHO, World Health Organization, USEPA, US Environmental Protection Agency

concentration was less than the WHO standard values in the all samples [Table 3], but there was a significant association between TSP and Pb concentration ($P < 0.001$). The positive relationship between Pb and suspended particles was reported by Rajasekhar *et al*.[18] In the previous studies conducted by Leili *et al*. and Arditsoglou *et al*. the reported concentration of Pb was less than the standard values of WHO.[13,17] Leili *et al*. studied TSP and PM_{10} concentration and their heavy metal content in the central area of Tehran. They reported that only PM_{10} concentrations in 3 days were higher than USEPA primary and secondary air quality standards.[13] In the study by Arditsoglou *et al*., the mean of Pb concentration was also reported to be below the standard values.[17] Based on the results of Pearson's correlation test, there was a reverse linear relationship between rainfall amount, wind velocity, and TSP.

CONCLUSION

This study showed that ambient air of Mobarakeh city, Iran, is contaminated with TSP. The high concentration of Fe and Ni in this area may be attributed to the nearby industrial emissions. Thus efforts should be made to control the atmospheric pollution in order to protect humans from hazardous health effects of these potentially toxic pollutants.

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