Assessment of Pb, Cd, and Zn in Isfahan's air dust during 2015-2017 (A case study: North, West, and East Stations of Isfahan)

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ABSTRACT

The present study aimed to measure the heavy metals existing in Isfahan's dust at three stations during 2015-2017. This study was carried out in three stations located at north and northwest, west and southwest, and east and southeast parts of Isfahan. In each station, 12 sediment traps were placed and the concentrations of lead (Pb), cadmium (Cd) and zinc (Zn) in these sediment traps were determined using atomic absorption spectroscopy (AAS). The highest and the lowest concentrations of Pb in air dust were observed to be 490.1 and 70 mg/kg in western and eastern stations of Isfahan province, respectively. The highest and the lowest concentrations of Zn were 860.4 and 150 mg/kg in 2015, respectively. The highest Cd concentration (8.1 mg/kg) in air dust was found in the northern part of Isfahan province, while the lowest concentration of this metal (0.7 mg/kg) was observed in the eastern region of Isfahan. Similar results were obtained for the heavy metals enrichment factor with a maximum and minimum of 3.8 and 0.8 in 2015, respectively. The results of this study confirmed that the effect of human activities is significant in increasing the concentration of heavy metals such as Pb, Cd and Zn in dust. The assessment results for the enrichment factor of heavy metals revealed the contamination of dust by heavy metals. Accordingly, further attention is required to identify and control the pollutants sources such as heavy metals in dust in order to prevent the resulting pollution.
Keywords: Dust, Cd, Pb, Zn, Isfahan's Air dust

Introduction

The phenomenon of dust is a regional and international problem, which is described as an environmental disaster. A natural dust storm, which often occurs in arid and semi-arid regions, might contain a large amounts of materials.[1] Low air quality caused by air pollution can be regarded as a great risk to the environmental quality and human health as it might lead to respiratory diseases and cardiovascular and lung cancer.[2,3,4] Among the different compounds existing in dust, the heavy metals such as lead (Pb), cadmium (Cd), and zinc (Zn) pose a high risk to human health.[3,5,6] At the high doses, Pb and Cd are toxic to the brain and can lead to encephalopathy. Lower doses of the metals cause peripheral nervous system toxicity, kidney damage, blood disorders, and hearing impairment. On the other hand, Pb and Cd are introduced as an animal carcinogen and probable human carcinogen,[7] by the International Agency for Research on Cancer (IARC) and the USEPA.

Depending on the source and the movement direction, dust particles can greatly carry heavy metals[8] so that the evaluating the concentrations of the heavy metals in these particles is of essence. Heavy metals may accumulate in the tissues of living organisms due to the lack of biological degradation. These metals are concentrated in the food chain, thus posing a major risk to the existing organisms above the food chain.[9,10]

Atmospheric deposit, sewage sludge, and animal and chemical fertilizers are the most important sources of heavy metals entering the soil.[11] Rajabi *et al*. evaluated the concentration of heavy metals in air dusty particles in Sanandaj, Khorramabad, and Andimeshk cities in western part of Iran and reported the content

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of heavy metals in these areas to be above the standard level.[1] Farahmand Kia *et al.* studied the concentration of heavy metals in the atmospheric deposit of Zanjan, Iran. They found that heavy metals diffusion by industries had a direct impact on the concentration of heavy metals in the atmospheric deposit, and that there was a high correlation between Pb and Zn due to the presence of Pb and Zn mines and industries in this region.[12]

Hosseini *et al.* examined the health risks of heavy metals for the suspended particles in the air at Kurdistan university of Medical Sciences and concluded that none of the heavy metals increased the risk of carcinogenic and non-carcinogenic diseases for the residents of the studied region.[8] Human beings are exposed to dust by ingestion, inhalation, and dermal pathway; therefore, heavy metals in dust can either directly or indirectly influence human health.[13,14]

Isfahan and its surrounding regions are considered as industrial areas. Although, there has been enough information about the status of soil contamination over the recent years in this region,[15,16,17] little information still exists about the air pollution. As the air pollutant concentration is constantly changing, it needs to be examined continuously. The adsorption of heavy metals through the soil-plant system has been studied several times; however, the dust heavy metal deposits accounting for 25-85% of the total input of heavy metals into the soil have been less studied.[18]

With daily increase of traffic, it is of paramount importance to check the polluted areas constantly. In this regard, the Environmental Protection Agency has managed to contribute to the continuous monitoring of pollutants by installing pollutant measurement stations. In many other regions, however, it has not been possible to permanently investigate their concentration using these instruments. Due to the presence of polluted industries and the existence of Pb and Zn mines in Isfahan, a continuously monitoring of the Pb, Cd and Zn concentrations is of importance due to the negative effect of these metals on human health. The sources of heavy metal pollution can be derived from direct industrial releases from vehicle and point sources followed by atmospheric deposition. Accordingly, this study was to evaluate the Pb, Zn and Cd concentrations in three stations located at north and northwest, west and southwest, and east and southeast parts of Isfahan province during 2015-2017.

Materials and Methods

This descriptive-analytical study was carried out to examine the concentration of heavy metals in atmospheric dust samples in north and northwest (Station No.1), west and southwest (Station No. 2) and east and southeast (Station No. 3) parts of Isfahan during 2015-2017. The sampling points were selected randomly to indicate the pollution status in each of the concerned regions. It should be noted that 12 sediment traps with a diameter of 32 cm and a depth of 12 cm were placed in each station. Sediment traps were covered by a plastic sheet with a mesh of 2×2 mm and held at a height of 33 cm from the roof surfaces of the houses. Sampling was carried out on November 2015 - 2017 at four stages per month. The mean concentration of Pb, Cd and Zn in the accumulated dust in the sediment trap was determined according to Ahmadi Doabi *el al.*[19]

In order to determine the effect of human resources on increased concentration of heavy metals in dust, enrichment factor was calculated through dividing the concentration of the metals in dust by their reported concentrations in non-polluted soil of the region.[18,20] Accordingly, the values of the enrichment factor were categorized into four classes based on the following Table.

Table 1. Enrichment factor level[19]

EF	EF<2	2<EF<5	5<EF<20	20<EF<40	EF>40
Pollution status	Low	Moderate	High	Very high	Extremely high

After performing laboratory analysis, the SPSS software Version 16 was used to describe the results and to obtain a summary of statistical information.

Results and Discussion

The statistical description of heavy metals concentrations in atmospheric dust samples is summarized in Table 2. Regardless of the study years, the dust heavy metals by concentration were Zn>Pb>Cd, respectively. However, the mean concentration of heavy metals in air dust was increased during 2015-2017. Throughout the studied years, the highest variation coefficient was observed for the Cd.

Table 2. Statistical analysis of heavy metal concentrations in air dust

Year	Statistical parameter						
	Element	Min	Max	Mean	Skewness	Range	CV
2015	Pb	70.0	490.1	229.9	0.5	420.1	50
	Cd	0.7	8.1	3.0	0.8	7.4	62
	Zn	150.0	860.4	472.3	0.4	710.4	39
2016	Pb	95.0	515.0	246.2	0.6	420.0	47
	Cd	1.0	9.2	3.3	0.7	8.2	57
	Zn	170.3	910.0	489.3	0.9	739.7	41
2017	Pb	125	540.0	254.0	0.6	415.0	45
	Cd	1.3	9.5	3.7	0.5	8.2	48
	Zn	230.0	940.0	506.3	0.9	710.0	35

The heavy metal distributions are shown by the study stations in Fig. 1. According to the results of this study, the highest and lowest dust Pb concentrations in 2012 were observed in Stations No. 2 and 3 with a mean concentration of 338.7 and 144.6 mg/kg, respectively. Wang et al. studied the isotopic composition of dust particles and reported that anthropogenic resources such as industries and mines are the main participants of atmospheric Pb.[21] Mahmoodi et al. also claimed that the high concentration of heavy metals in atmospheric deposit reflects the human input of these metals caused by rapid industrialization and urban expansion.[18]

Basically, the western part of Isfahan province is geologically located at a Pb and Zn rich zone; therefore, the Pb and Zn concentrations are high in this region.[18] The average concentration of Pb dust at Station No. 1 was 206.3 mg/kg. In addition, a significant increase in Pb air dust concentration was observed at the three concerned stations during 2015-2017. The average Pb dust concentration was changed from 206.3 in 2015 to 229.7 and 234.6 mg/kg in 2016 and 2017 at Station No. 2, respectively. Similar results were observed for the two other studied stations.
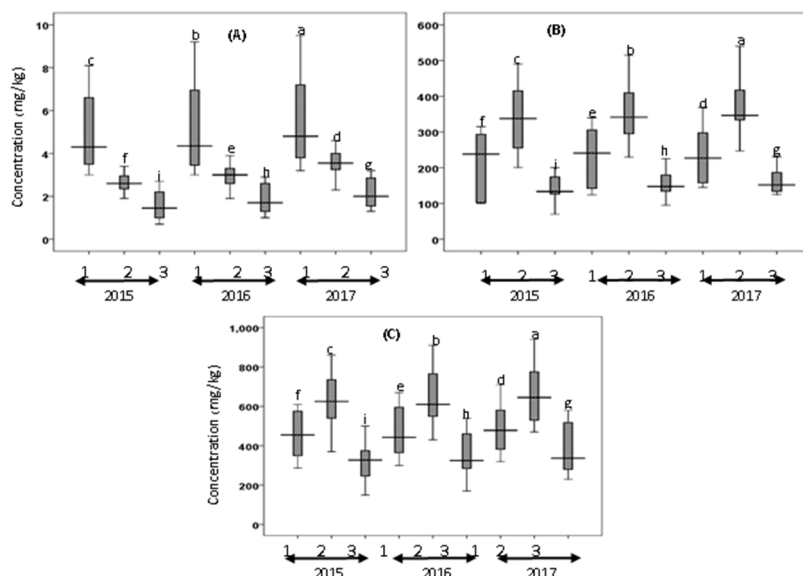

Fig. 1. Boxplot of Cd (A), Pb (B), and Zn (C) in study area. 1, 2 and 3 represent the stations concerned in this study

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According to the results indicating the increasing concentration of heavy metals and its important role in human health, regular investigations of the soil and air heavy metal concentration seems to be importance. Mahmoodi *el al.* reported that the ratio of Pb entering through dust in Isfahan province was between 35 and 91%, which might vary based on different land uses. Moreover, They also noted that highest portion of Pb and Cd belonged to dust heavy metal content in Khomeini Shahr and Falavarjan, Isfahan, Iran.[18]

According to the present results, the mean concentration of dust Pb in the studied region is higher than that in Karaj,[22] Ahvaz,[23] Kerman[24] and Boshehr,[25] Iran. It should be noted that the lowest concentration of dust Pb was observed in the eastern part of Isfahan, which is far from industrial pollutants. The atmospheric concentration of heavy metals depends on many factors such as climatic factors and distance from the sources such as metal industry or large roads, and it is extremely variable and in need of periodical measurement. Meanwhile, high levels of some heavy metals in street dust can be attributed to factors such as micro-rubber particles and brake linings of cars.[26]

The highest concentration of air dust Cd was observed in the northern and northeastern regions of Isfahan province due to the high traffic flow in these regions. Mahmoodi *el al.* reported that 47 percent of soil pollution was caused by the dust Cd pollution in the northern and northeastern regions of Isfahan. The results of their study revealed that the air heavy metals were higher in November and December than the other months due to the pollution caused by heating devices as well as the incidence of temperature inversion followed by increased suspended particles in the atmosphere.[18] A low level of Cd in the eastern region of Isfahan is expected due to the lack of industrial activities, even though, a significant increase in dust concentration of Cd was also observed during 2015-2017, which can be attributed to the different factors such as road traffic.[23] The dust concentration of Cd in the present study was greater than the global mean of soil concentration of Cd (0.7 mg Cd/kg soil).[18]

According to Karimian *et al.*, the dust concentration of Cd in Isfahan was 3.2 times greater than Ahvaz's dust concentration of Cd. This, however, varies in different times and spaces.[23]

As shown in Fig. 1, the highest and lowest dust concentrations of Zn were observed in western and eastern station of Isfahan with a mean of 658.6 and 377.77 mg Zn/kg in 2017, respectively. It is worth noting that there was also a significant increase in dust concentration of Zn during 2015-2017. Dayani *et al.* reported that mining activities such as extraction and transportation in the south and southwest of Isfahan enhanced the possibility of the Zn and Pb pollutions.[27] Accordingly, the dust concentration of Zn found in the present study was much greater than those reported in Ahvaz,[23] Kerman[24] or Shiraz[28] Iran.

Fig. 3 indicates that the mean values of Pb enrichment factor were 9.39, 9.8, and 10.1 during 2015-2017, respectively. The similar results were observed for the Cd concentration, and the mean enrichment factor changed from 1.83 in 2015 to 2.16 in 2017. Similar trends were also observed for Zn enrichment factor (Fig. 2).

A significant increase in the mean of Pb enrichment factor can be attributed to the role of human activities.[28] Ahmadi Dubi *et al.* concluded that enrichment factor was one of the most important indicators determining the pollution status of the region. They observed that the industrial and traffic activities are the main factors increasing the Pb enrichment factor in the region.[19]

Based on the present study, the highest amount of Pb enrichment factor with a mean of 13.5 in 2015 was observed in Station No. 2, which is located in Bama Zn and Pb mine. The Pb enrichment factor showed a significant increase during 2015-2017, showing a high correlation with the dust Pb concentration. Lu *et al.* concluded that car traffic and industrial activities could increase the enrichment factor.[29]

In spite of the Pb removal from gasoline, a significant increase in the Pb concentration is still observed in the studies area during 2015-2017, indicating that the car burnout could be considered as a factor increasing the air Pb

concentration. On the other hand, more time is needed to reduce the concentration of Pb that has been already accumulated in the air. Ahmad and Eziga found that the content of heavy metals in urban dust of Dhaka (China) could be attributed to the dust generated by urban traffic.[30]

Mahmoodi *et al.* reported that the car traffic is the major source of Cd dust pollution in Isfahan.[18] As the northern region of Isfahan province is one of the main entrance highways of this province, the Cd pollution in this region has been expected. Although the traffic problems have been relatively resolved over the recent years through adopting some useful approaches, such as the construction of North-South bridges, the Cd concentration still increases in the air during the peak hours of

traffic in this region. Station No. 3 was placed in the low enrichment factor group (Table 1).

The highest Zn enrichment factor belonged to Station No. 2, that could be related to the Bama Pb and Zn mine. The concentration of Zn enrichment factor in Station No.1 varied between the those observed in Stations 2 and 3, even though, the enrichment factor in this station was classified in the high enrichment factor group. Keshararzi *et al.* noted that the Zn enrichment factor in Shiraz's air dust was above 10, which is mainly from traffic sources.[28] Lu *et al.* mentioned that industrial activities and traffic have significant impacts on increasing Zn enrichment factor.[29] Based on Mahmoodi's *et al.* findings, there is a significant increase in the Zn enrichment factor, which would be dangerous to human health.[18]
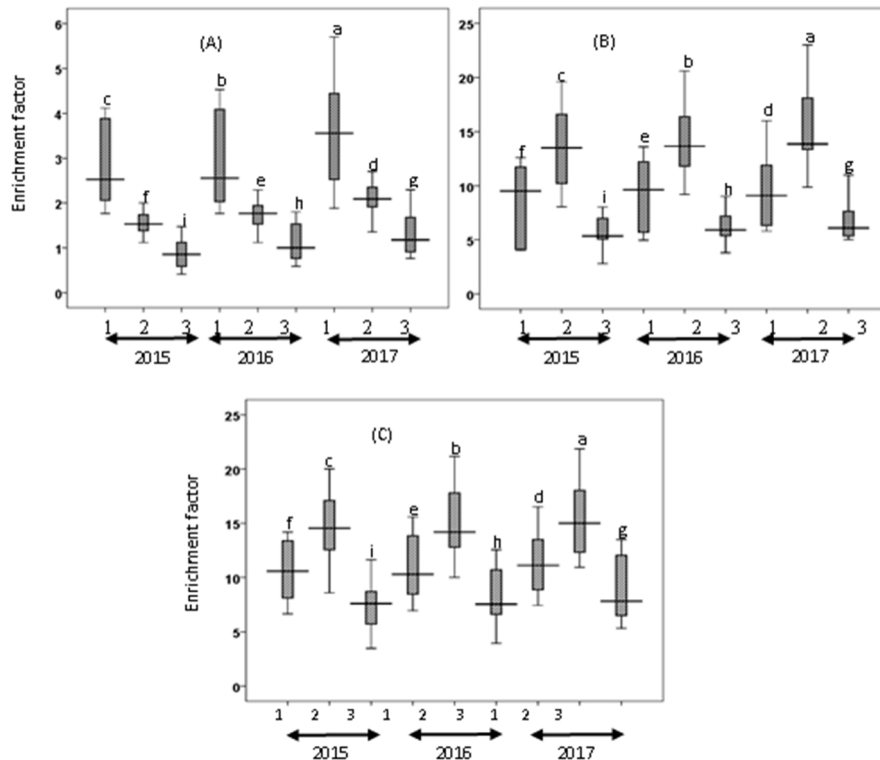

Fig. 2. Boxplot of Cd (A), Pb (B) and Zn (C) enrichment factor in the study area. 1, 2 and 3 represent the stations concerned in this study, respectively

Conclusion

The results of this study indicated that human activities could play an important role in increasing air pollution. Among the stations concerned in this study, the highest Pb dust pollution was observed at the west and

southwest stations of Isfahan province. The presence of Pb and Zn in industries and mines can be a major source of air pollution. The highest concentration of dust Cd was observed in the northern region of Isfahan, which contains a lot of traffic from the northern entrance of this

city. Despite the aforementioned reasons, season, industry pollution, and increasing car traffic are other factors that constantly affect air quality and need to be constantly monitored.

Authors' contributions

All authors contributed equally to the study and critically reviewed, edited, and approved the manuscript.

Competing interests

The authors declare that they have no competing interests.

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