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ORIGINAL RESEARCH ARTICLE

Lead concentration in dust fall in Zahedan, Sistan and Baluchistan Province, Iran

Sara Abdollahi[1], Akram Karimi[2], Meysam Madadi[3], Saeid Eslamian[4], Kaveh Ostad-Ali-Askari[5*], Vijay P. Singh[6]

[1]*MSc in Environmental Sciences, Department of Environmental Sciences, Yazd University, Yazd, Iran.*

[2]*MSc of Environmental Sciences, College of Environment, Department of Environment, Karaj, Iran.*

[3]*MSc of Environmental Sciences, Department of Environmental Sciences, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran.*

[4]*Department of Water Engineering, Isfahan University of Technology, Isfahan, Iran.*

[5]*Department of Civil Engineering, Isfahan (Khorasgan) Branch, Islamic Azad University, University Blvd, Arqavanieh, Jey Street, P.O. Box:81595-158, Isfahan, Iran. E-mails: koa.askari@khuisf.ac.ir; kaveh.oaa2000@gmail.com*

[6]*Department of Biological and Agricultural Engineering & Zachry Department of Civil Engineering, Texas A and M University, 321 Scoates Hall, 2117 TAMU, College Station, Texas 77843-2117, U.S.A.*

ABSTRACT

Dust is one of the atmospheric pollutants that have adverse environmental effects and consequences. Dust fall contains particles of 100 microns or even smaller ones, which fall from the atmosphere onto the earth surface. The aim of this study is to determine the concentration of lead in dust fall samples in order to study the pollution level of this element in Zahedan, Sistan and Baluchistan Province, Iran. Therefore, sampling was carried out using 30 marble dust collectors (MDCO) for 3 months in the spring of 2015 to investigate the quantitative variation and spatial analysis of lead content in dust fall. These dust collectors were placed at 30 stations on the building roofs with a height of approximately 1.5 meters across the city. According to the results, the mean lead concentration in the spring was 90.16 mg/kg. In addition, the zoning map of lead content shows that the lowest level of lead was measured at Imam Khomeini station while the highest amount of lead appeared in Mostafa Khomeini station.

Keywords: Dust Fall; Lead Content; Pollution; Zahedan

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1. Introduction

Rabid urbanization and continued demand for infrastructure development in urban areas have led to disturbances and as a result, a significant decrease in the quality of urban environments[1]. Transportation development and associated environmental issues are important concerns for all countries throughout the world. Such development has many benefits, but it also contributes to enormous adverse impacts on the environment. The environmental problems caused by traffic are mainly due to highway toxic emissions, which will inevitably lead to air pollution. Traffic is responsible for the intense emission of a wide range of pollutants, especially heavy metals[2]. The phenomenon of dust storms is one of the serious problems in various regions in the world, including Iran[3]. This is while the largest part of dust in the atmosphere occurs with the origin of fine-grain particles. These particles are more prevalent in arid and

semi-arid regions of the world. In fact, the creation of dust can be a response to the change in the land cover. However, the role of human activities along with the natural conditions of the geographic environments should not be ignored[4]. The aim of this study is to determine the concentration of lead content in dust fall samples to investigate urban pollution of this element. Today, there are two theoretical and experimental methods to measure the dust fall. In the experimental method, dust collectors are used to collect horizontal and vertical dust. Comparison of horizontal and vertical collectors shows that the marble dust collector (MDCO) has the highest efficiency for collecting dust particles[5].

The marble dust collector designed by Gunner in 1975 is widely used in many researches. This device consists of a plastic container and one or two rows of glass balls, which can be mounted on the ground or attached to a vertical base. The plastic container is used in many different types, among which circular containers are better than rectangular ones, since the effects of wind on rectangular containers are more pronounced. The diameter of the marble used is 1.6 centimeters[6]. Glass marbles are suitable for depositing dust applications as standard equipment due to their convenience to use, accessibility, and maintenance-free characteristics[7].

In addition, dust is considered as one of the most important atmospheric phenomena and natural disasters, and has received significant attention from many scholars and researchers in different fields of atmospheric science. The origin and mechanism of formation, transfer, diffusion and the consequences of this phenomenon are studied by various techniques and methods[8]. In recent years, it seems that there has been a change in the frequency of occurrence of this climatic hazardous phenomenon, which has caused problems in some parts of our country. The frequency of dust at a point depends on the size and diameter of the particles, in addition to the wind intensity, speed and dryness of the soil particles[9]. Studies on the abundance of dusty days in the country indicate that Iran Central basins have the highest frequency of dusty days[10]. Major sources of dust in the Middle East and Southwest Asia are the Arabian Peninsula with deserts surrounding it, most of which are active during the period from April to July[11]. Generally, the soils of arid regions are vulnerable to erosion due to the lack of organic and colloidal matter. Therefore, dust is the most important natural source of air pollution in most cities located in arid and semi-arid regions of Iran[12].

Dust fall refers to the dust that falls from the atmosphere onto the surface of the earth. By studying the dust fall, we can indirectly examine the contamination of total suspended particles[13]. Heavy metals are classified as one of the most hazardous groups of anthropogenic pollutants due to their toxicity and persistence in the environment[14]. In general, two types of pollutants were detected in dust: the first one consisting of CO, NO_2, SO_2, heavy metals, especially lead and cadmium, and the second group containing chemical, physical and biochemical components[15]. Human activities lead to increased levels of heavy metals in the environment. These metals accumulate in street dust, soil and surface water and affect the global ecosystem[16,17]. Heavy metals formed as fine and light compounds suspend in the atmosphere, dissolve during precipitation events and fall onto the surface of the earth. However, the coarse and heave portion of metal compounds settled down on the ground surface over time. In general, the presence of heavy metals in the atmosphere or in airborne dust increases the concentration of these elements in the body of inhabitants in the infected areas[8].

Lead is one of the heavy metals that are introduced to the environment by human in different ways. Activities such as ammunition manufacturing, casting, dyeing, leaded petrol production, sealing the pipes, cable coating production, lead melting and fusion, lead arsenate used in agricultural, battery production, brass alloys production, the combustion of leaded petrol in motor vehicles, etc. are the introducers of this hazardous substance into the environment[18]. In recent years, because of the elimination of lead from petrol, its emission into the urban environment has decreased significantly; however, the accumula-

tion of its previous uses has remained in the envir onment[19].

2. Literature review

Salamatian studied the quantitative variation of the dust fall and determined some of its physical and chemical properties in Isfahan, Iran. Sampling was done using a marble dust collector during a six-month period. The results showed that the average dust fall weight in Isfahan was 12 gr/m^2 and 17 gr/m^2 in winter and spring, respectively[8].

Akbari *et al.* studied the dust fall of Behbahan, Iran, using a marble dust collector during September and October. They concluded that the amount of dust fall in September is higher than in October. Also, some factors such as changes in Urban cover, roughness of the city, the streets orientation to the dominant winds and the level of traffic were considered effective in urban dust fall level[3].

Jia *et al.* examined the characteristics of dust fall and the identified the source of dust in arid and semi-arid parts of northern China. They studied 29 sites and identified 26 elements in the dust. Spatial and temporal changes were observed in these particles, and they found that these elements were in the highest level in spring, since the most dust storms occur in this season[6].

3. Materials and methods

3.1 Study area

The present study is conducted in Zahedan City (Sistan and Baluchistan Province), with an area of about 557 km^2 and a population of 574,000. The height of this city from the sea level is 1385 m with a longitude of 60º51′25″ E and latitude of 29º30′45″ N.

3.2 Sampling of dust fall and determining the lead content

Systematic random sampling method was used to determine the sampling points so that 30 stations were selected across the city. Marble dust collector was used to investigate the dust fall. The sampler was placed at a height of 1.5 meters from the roof surface. **Figure 1** shows the location of sampling stations. Sampling was carried out for three months from April to June 2015. At the end of each month, trapped dust was carefully collected. The concentration of lead content in dust samples was measured using a flame atomic absorption spectrometer Model Analytic jena-350.

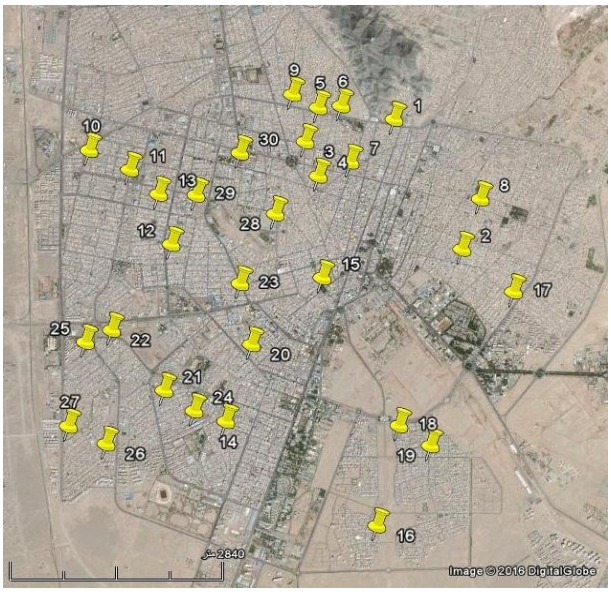

Figure 1. The location of sampling stations on Google Earth**.**

3.3 Isolation and spatial distribution of lead content in dust fall

Pollination index (*PI*) and ecological risk (*Er*) were used to determine the status of lead contamination (Equations 1 and 2).

$$PI = Cn/Bn \quad (1)$$

$$E\,r = Tr.PI \quad (2)$$

Where, *Cn* is lead concentration in each sample; *Bn* is the background level of this metal in the soil, and the *Tr* is the toxic response factor. According to Hakanson, the value of *Tr* for lead is 5. **Table 1** shows how these indicators are categorized.

According to the results obtained from different stations, the zoning map of the study area was prepared by Kriging method using Arc GIS 9.3 (**Figure 2**), so as to investigate the spatial distribution and frequency of lead across the city.

Table 1. Indices and the environmental potential pollution degree for heavy metals[8,20,21]

Air quality index	*PI* index	Environmental potential pollution risk	*RI* index	Environmental pollution risk for each metal	*Er* index
Low	$PI < 1$	Low risk	$RI < 150$	Low risk	$Er < 40$
Moderate	$1 < PI < 3$	Moderate risk	$150 < RI < 300$	Moderate risk	$40 < Er < 80$
High	$PI > 3$	High risk	$300 < RI < 600$	High risk	$80 < Er < 160$
-	-	Very high risk	$RI > 600$	Very high risk	$160 < Er < 320$

4. Results and discussion

4.1 The amount of lead content in the dust fall

Table 2 shows descriptive statistics of lead content, and **Table 3** shows the pollution index and the ecological risk associated with lead content in spring.

Table 2. Descriptive statistics of lead content in different months in spring season (mg/kg)

	Arithmetic mean (mg/kg)	Standard deviation	Minimum	Maximum	Skewness	Kurtosis	k-s (p-value)
April	99.13	11.74	74.70	116.10	-0.226	-0.686	0.51
May	85.10	12.30	37.73	103.25	-2.368	7.695	0.05
June	86.27	12.98	50.75	99.85	-1.598	2.092	0.20

Table 3. Indices of lead content in dust fall in spring 2015 (mg/kg)

Average lead content in spring	Pollution index in spring	Ecological risk in spring
90.16	1.11	5.55

As shown in **Table 3**, the value of *PI* in spring is greater than 1, so it is classified as the moderate pollution. According to the figure, the lead content in the dust fall in spring in the range of Mustafa Khomeini, Enghelab and Badr stations is higher than that in the rest stations. While the lowest amount of lead content in dust fall was measured at Imam Khomeini, University and Jam-e-Jam stations (**Figure 2**).

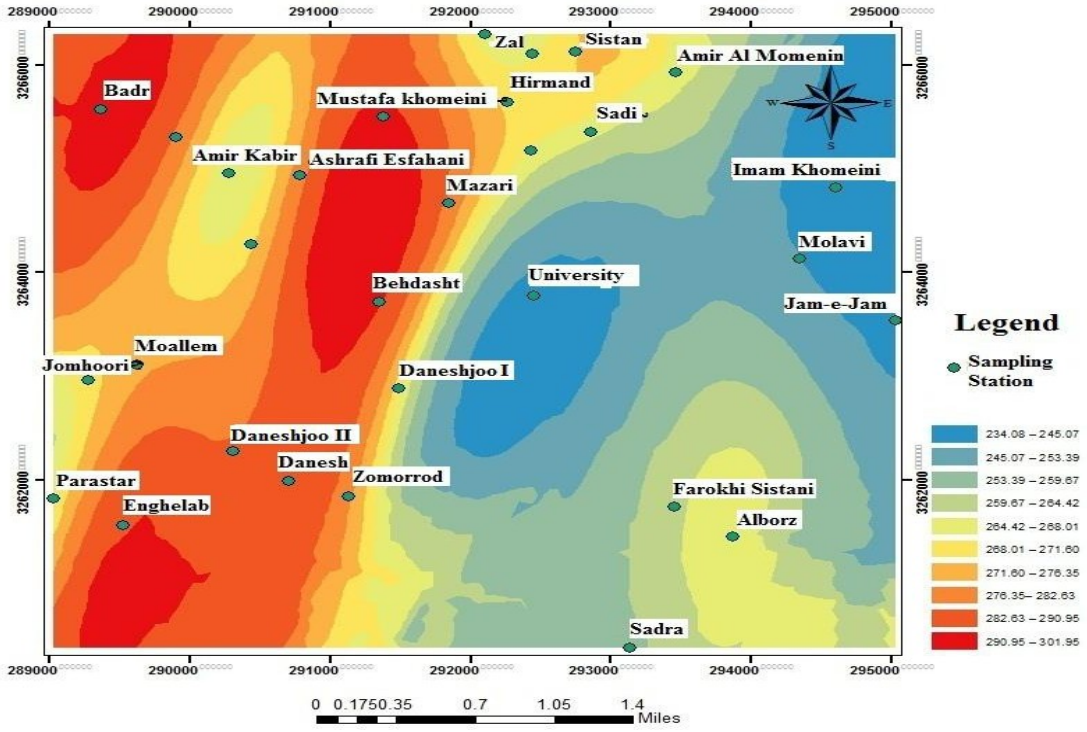

Figure 2. Zoning map of lead in the dust fall in spring.

5. Conclusion

As mentioned above, in most cities in arid and semi-arid regions of Iran, the main cause of air pollution is dust. Lead is one of the most harmful metals for human health. The results of this study show that the concentration of lead in Zahedan dust exceeds the values previously measured in Yazd and Behbahan[3]. The results of zoning of lead content in dust fall showed that the highest concentration of lead was measured in Mostafa Khomeini station while the lowest concentration was recorded in Imam Khomeini station. Studies indicate that the main source of lead pollution in air is additive matter of vehicle fuel. Therefore, high traffic of motor vehicle can be a cause of increased concentration of heavy metals.

6. Suggestions

In this study, we tried to calculate the amount of lead content the dust falls in Zahedan City. It is suggested that other heavy metals such as zinc, nickel, and copper in the dust of Zahedan City in Sistan and Baluchistan Province be investigated in order to obtain information on their pollution potential and environmental hazards. Also, exposure of citizens to these elements can be addressed. In addition, the transmission trend of these elements could be found by comparing the results with the research carried out in other border cities of Iran. Considering that in some of the studied stations the concentration of heavy metals exceeds the standard, it is suggested that the origin and emission source of these elements should be determined in future researches and solutions for controlling, reducing and preventing their effects could be provided.

Conflict of interest

The authors declare that they have no conflict of interest.

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