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Investigation of pollution and ecological risk of heavy metals (cadmium, chromium, copper, nickel and lead) in the falling dust of Tehran, Iran

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ABSTRACT

The study of heavy metals in dust fall is very important due to effects on human health. The purpose of the present study has been to determine the level of contamination and ecological risk of heavy metals such as Cd, Cr, Cu, Ni, Pb in the falling dust of Tehran city, and investigation spatial distribution of pollution on the studied stations. Dust fallout samples were collected using Marble Dust Collector (MDCO) from 28 different locations across the Tehran city, during the statistical period (from December 22nd, 2017 to June 21st, 2018). Contamination factor(CF), pollution Load index(PLI), The potential ecological risk coefficient(Er) and The potential toxicity response index(RI) were used to identify the level of contamination and ecological risk of heavy metals. The amount of (Cf), (PLI), (Er) and(RI) for the heavy metals in the dust fall in winter and spring 2018 followed the order of Pb>Cd>Cu>Cr>Ni. The concentrations of Lead, Copper and Cadmium in winter were significantly higher than those in spring. Stable air, temperature *inversions* and more heating devices are used in winter, causes that heavy metals are increased in this season. Areas located in the east of Tehran have the highest pollution and ecological risk in terms of cadmium, copper, nickel and lead. Most of the chromium contamination exists from the central areas to south of Tehran. Tehran's prevailing wind direction and Tehran's topographic pattern, mines, factories and industries located in the west and southwest of Tehran have main role in polluting Tehran's falling dust with heavy metals.

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Introduction

Falling dust is considered a general and an important component of atmospheric particles, and due to their gravitation, these particles fall to the ground (Berivan, 2021). By studying dust fall, we can indirectly identify the contamination of all suspended particles (Hai *et al.,* 2008). One of the main reasons for study of falling dust is the inhalation of these particles by individuals, and most of the dust is contaminated with heavy metals, and people are exposed to the health risks associated with these contaminants (Apeagyei *et al.,* 2011., Aguilera, 2019., Arsalani *et al.,* 2020). There have been many reports of human health being compromised by dust, especially for children, due to their lower tolerance to toxicity, as well as the consumption of significant amounts of soil through the mouth (Zheng *et al.*, 2010., Hu *et al.*, 2011). So dust fall is recognized as a significant source of pollution (Charlesworth *et al.*, 2003). Dust fall originate from both natural and human sources. Natural resources are generated by the weathering of rocks, soil erosion, volcanic ash and sea salt. Anthropogenic sources are generated by the brake and tire wear, exhaust emission (Budai and Clement, 2018) and polluting particles released by industries (Aguilera *et al.,* 2019).

Dust particles have a high ability to carry heavy metals, depending on their origin and path (Khuzestani and Souri, 2013). The composition of the falling dust is complex and variable. The concentration of heavy metals in falling dust varies greatly (Sami et al, 2006). Heavy metals are one of the most dangerous group of man-made pollutants due to their toxicity and long-term stability, and they are important in low concentrations due to their non-degradability and physiological effects on humans and other organisms (Kumar Sharma *et al.*, 2008., Csavina *et al.*, 2012., Ali *et al.*, 2019). The study of heavy metals in dust fall is very important because of its effect on human health (Shi *et al.*, 2010., Zarasvandi *et al.*, 2011., Yang *et al.*, 2020., Kumari *et al.*, 2021). There are various natural and artificial sources of heavy metals in the environment. These metals are often of anthropogenic (Csavina *et al.*, 2012), such as fossil fuel burning, traffic emission, gas emitted from motor vehicles and other machineries (Taghavi *et al.*, 2019., Berivan, 2021), heavy traffic, traffic light and braking frequency are causing increasing concentration of copper and lead (Behravesh *et al.*, 2015).

Today, there are two methods of theoretical and laboratory calculations to estimate the measurement of dust fall. In the laboratory method, trap-sediment is used to collect horizontal and vertical dusts (Sow *et al.*, 2006). Among all the sediments tested in the Jia and Huang's study, the marble dust collector (MDCO) was one of the samplers that showed greater potential for dust absorption than others (Jia and Huang, 2008). Measurement of falling dust by Marble Dust Collector is carried out for studies such as spatial and temporal analysis of dust, its physical composition and chemical analysis and determination of its harmful elements (Modaihsh *et al.*, 2013., Azimzadeh *et al.*, 2017., Arsalani, 2019). Also to determine contamination levels of heavy metals in falling dust used Contamination Factor (CF), Pollution Load Index (PLI) (Harb *et al.*, 2015., Saeedi *et al.*, 2012., Gurumoorthi and Venkatachalapathy, 2016., wang *et al.*, 2018), and to assess the ecological risk of heavy metals in falling dust used potential ecological risk coefficient (Er) and potential toxicity response index (RI) (Yi *et al.*, 2011., Saeedi *et al.*, 2012., Kamani *et al.*, 2017., Zhou *et al.*, 2019).

The HYSPLIT Model is considered as one of the most widely used meteorological models for determining the transport pathways of dust, and to evaluate atmospheric conditions, and to detect dust sources (Chen *et al.*, 2013., Cao *et al.*, 2015., Ha *et al.*, 2017., Aili *et al.*, 2021). The HYSPLIT model uses puff or particle approaches to compute trajectories, complex scattering and deposition. The model calculation method was combination of Eulerian and Lagrangian approaches (Ashrafi *et al.*, 2014).

The metropolis of Tehran is one of the major cities in the world that it is currently facing very air pollution problem. It has a population of over eight million people. In recent years, various studies have been conducted on air pollution in this metropolis. But not many studies have been done on investigation of pollution and ecological risk of heavy metals in the dust fall. Therefore, the purpose of the present study was to determine the level of contamination and ecological risk assessment of heavy metals such as Cd, Cr, Cu, Ni, Pb in the dust falling of Tehran city and investigation spatial distribution of pollution on the studied stations. Due to heavy metals are an important component of urban environmental pollution. To create a safer and healthier environment for the mass of the present population, having comprehensive information on dust fall can help us manage sustainable development and create a safer environment for residents.

Material and methods

Study area

Tehran's metropolis is the capital and largest city of Iran. It covers an area of over 733 km^2, including 22 zone. It is located at 51 degrees and 6 minutes to 51 degrees and 38 minutes east of the longitude, and 35 degrees and 34 minutes to 35 degrees and 51 minutes north of the latitude (fig 1). The Tehran city is surrounded by mountains and deserts, from north by the Alborz mountain range, and from east Bibi-Shahrbanu mountain, and from west and south the flat plains of Shahriar, Varamin and Rey. The shape of Tehran city is related to this location. The population of Tehran in 2016 was 8693706[1].

Data and methods

The trap was used in this study was Marble dust collector (MDCO). In this study, for proper distribution of sediment traps throughout the city, a sediment trap was installed in each zone and also two traps were installed in areas that were more extensive. Dust fallout samples were collected using Marble Dust Collector (MDCO) from 28 different locations across the Tehran city during the statistical period (from December 22nd, 2017 to June 21st, 2018). XRF[2] analysis was used to identify and to determine the concentration of heavy metals (Cd, Cr, Cu, Ni, Pb) in the collected dust fall. The kriging interpolation method was designed for spatial analysis. Among the methods of interpolation, kriging was found to be the most appropriate because it considers both regional and local structures (Arsalani *et al.*, 2019). Statistical analysis of data during the study period showed that the concentration of heavy metals (Cd, Cr, Cu, Ni, Pb) had a regional behavior (trend), so universal kriging was used.

Daily wind velocity and direction data were also obtained from the Meteorological Organization during six months, (a) statistical period (from December 22nd, 2017 to June 21st, 2018), for statistical analysis of data, used software SPSS, and with the help of the WRPLOT software the wind rose plot was drawn.

[1] Statistical Center of Iran (SCI), 2016
[2] Xray Fluorescence spectroscopy

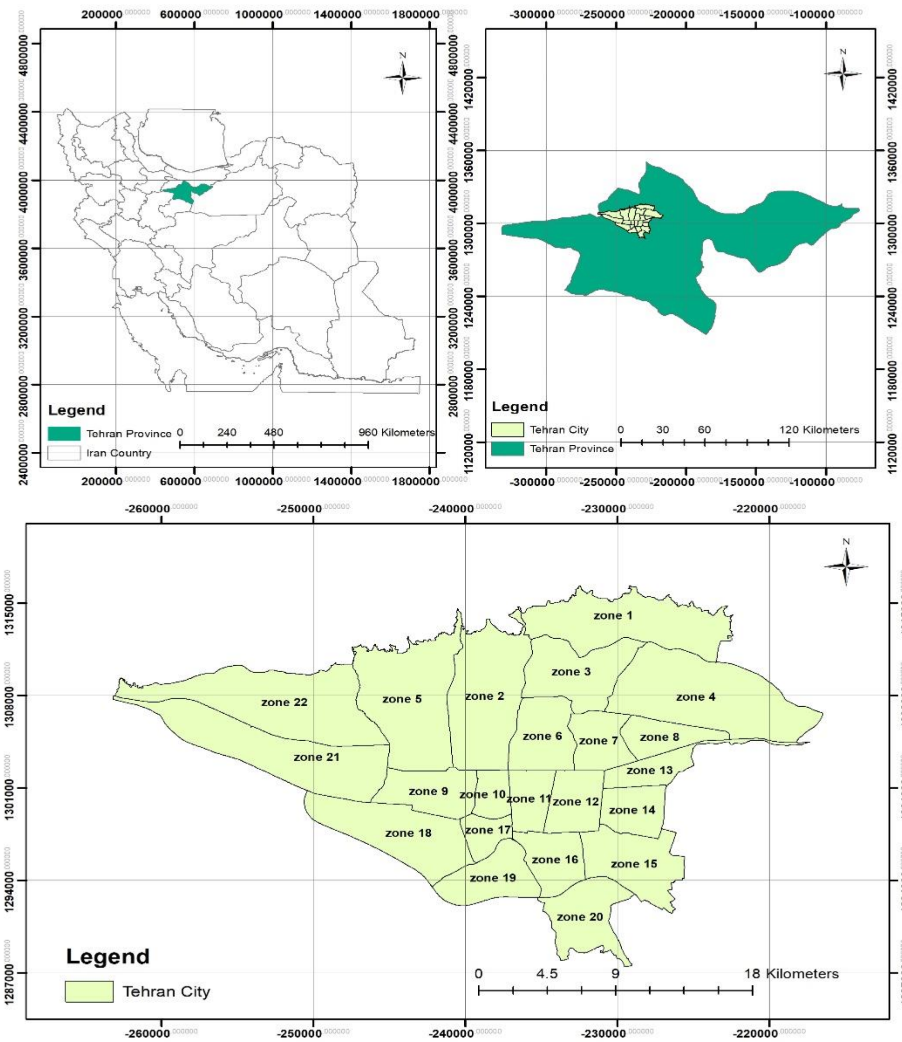

Figure 1. Geographical Location of Tehran in Iran

The HYSPLIT[3] Model data is used to examine the forward motion of atmospheric pollutants. The FNL data set was used to run the model. The FNL (Final) data are actually NCEP[4] data processed by the NOAA[5] affiliated air resources laboratory. These data are available with 1 * 1degree horizontal resolution for 26 pressure levels (1000-100 hp) and with the 6-hour time step from July 1999. It is necessary for dust modeling that the primary areas of emission sources identified. In this model, desert areas are defined by default, and according to the type of surface soil in these areas (sand, silt, clay, etc.) there is a special sensitivity to wind erosion. The modeling process begins after determining the desert resources by making model settings and entering meteorological data. The basis of this model is using wind speed and direction data. Thus, after

[3] Hybrid Single Particle Lagrangian Integrated Trajectory
[4] National Centers for Environmental Protection
[5] National Oceanic and Atmospheric Administration

processing and entering the data into the model, the emission path for selected days along with the dust phenomenon simulated and tracked.

The Contamination factor (CF) is an important tool for identifying the level of contamination (El-Sherbiny *et al.*, 2019). The contamination factor (Cf) was calculated as follows

$$CF = \frac{Ci}{Coi} \quad (1)$$

Cf is the contamination factor, C_i is the metal concentration in dust falling, Co_i is the background concentration. Different Cf classifications are delineated in Table 1

Table 1. contamination factor Categories based on Cf (Hakanson, 1980)

Cf	Categories
Cf < 1	low contamination
1 ≤ Cf < 3	moderate contamination
3 ≤ Cf < 6	considerable contamination
Cf > 6	very high contamination

The pollution Load index (PLI) is provided to determine the level of contamination and can provide an estimate of the level of contamination of the metals. The pollution Load index (PLI) was calculated as follows

$$PLI = \sqrt[n]{CF1 * CF2 * CF3 * \ldots * CFn} \quad (2)$$

PLI is pollution Load index, n is number of heavy metals and Cf is the contamination factor. The PLI value of >1 is polluted, whereas<1 indicates no pollution (Harikumar *et al.*, 2009).

The two formulas mentioned above require a value called background value, which in some studies has used heavy metal concentrations in the earth's crust as background values (Kartal *et al.*, 2006). This study used the values exist in Earth's crust as background values.

The potential ecological risk coefficient (E_r) was first used by Hakanson for determining the potential ecological risk coefficient of heavy metals (Hakanson, 1980). The potential ecological risk coefficient (E_r) was calculated as follows

$$Er = T_r \times C_f \quad (3)$$

Table 2. Potential ecological risk Categories based on Er (Kamani et al, 2017)

E_r	Categories
E_r < 40	Low
40 ≤ E_r < 80	Moderate
80 ≤ E_r < 160	Considerable
160 ≤ E_r < 320	High
320 ≤ E_r	Very high

The potential toxicity response index (RI) is a method for calculating the sum of different risk factors and is commonly used to evaluate the toxicity of various heavy metals in soil (Hakanson, 1980). The potential ecological risk index (RI) was calculated as follows:

$$RI = \sum_{i=1}^{m} Er \quad (4)$$

RI is The potential toxicity response index, Er is the potential ecological risk factor. Different RI classifications are delineated in Table 3

Table 3. The potential toxicity response index categories based on RI (Saeedi *et al.*, 2012., Hakanson, 1980)].

RI values	Categories
RI < 150	Low ecological risk
150 ≤ RI < 300	Moderate ecological risk
300 ≤ RI < 600	Considerable ecological risk
RI ≥ 600	Very high ecological risk

Results

Descriptive statistics of heavy metal concentrations (Cd, Cr, Cu, Ni, Pb) in the falling dust in Tehran city were calculated. In the study, in order to investigate the heavy metal pollution in Tehran's falling dust, we made a comparison between the concentrations of heavy metals in this study with similar studies in other industrialized countries, as well as the average concentrations of metals in the earth's crust and the standard of soil pollution in Iran. The average concentration of heavy metals in dust falling of Tehran in winter and spring followed the order of Pb>Cu>Cr>Ni>Cd. Compared to other cities in the world, this average showed high values, especially in winter (Table 4).

Table 4. comparison of mean concentrations of heavy metals in this study with similar studies in other industrialized countries, the mean concentrations of metals in the earth's crust and the standard of soil pollution in Iran (The unit is mg/kg)

Location [References]	Cd	Cr	Cu	Ni	Pb
Tehran (Iran) in winter[Present study]	3.70	103.70	199.36	62.03	191.63
Tehran (Iran) in spring[Present study]	1.86	160.83	115.63	58.25	125.79
Birmingham (UK) (Charlesworth *et al.*, 2003)	1.60	-	466.90	41.10	48.00
London (UK) (Schwar *et al.*, 1988)	3.50	-	155.00	-	1030.00
Kuala Lumpur (Malaysia) (Ramlan and Badri, 1989)	2.90	-	35.50	-	2466.00
Madrid (Spain) (De-Miguel *et al.*, 1997)	-	61.00	188.00	44.00	1927.00
Ottawa (Canada) (Rasmussen *et al.*, 2001)	0.60	59.00	188.00	19.00	68.00
Kavala (Greece) (Christoforidis and Stamatis, 2009)	0.20	232.40	172.40	67.90	386.90
Nanjing (China) (Hu *et al.*, 2011)	-	126.00	123.00	56.00	-
Shanghai (China) (Wang *et al.*, 2009)	1.24	157.00	-	-	287.00
South China (Leung *et al.*, 2009)	5-10	30-50	-	-	800-100
China (Wei *et al.*, 2009)	1.17	54.28	94.54	43.28	53.53
Mexico (Meza-Figueroa *et al.*, 2007)	4.24	11.15	26.34	4.70	36.15
the standard of soil pollution in Iran[6]	2.00	110.00	100.00	50.00	50.00
the earth's crust (Niencheski *et al.*, 2002)	0.20	100.00	50.00	80.00	14.00

The Kolmogorov-Smirnov test and the Shapiro-Wilk test were used for testing normality. Parametric test (t-test) was used to compare differences between two groups in normal distributions. And, non-parametric test (Mann-Whitney) was used to compare differences between two groups in non-normal distributions.

Cadmium concentrations are higher than standard levels at 74% of stations in winter, and at 28% of stations in spring. Investigation statistically significant differences between cadmium

[6] Department of Water and Soil, Iran

concentrations in winter and spring with Mann-Whitney test showed that there was a significant difference between the means of the two seasons. Chromium concentrations are higher than standard levels at 40% of stations in winter, and at 44% of stations in spring. Investigation statistically significant differences between chromium concentrations in winter and spring with Mann-Whitney test showed that there is no significant difference between the means of the two seasons. Copper concentrations are higher than standard levels at 88.88% of stations in winter, and at 72% of stations in spring. Investigation statistically significant differences between Copper concentrations in winter and spring with independent t-test showed that there is a significant difference between the means of the two seasons. Nickel concentrations are higher than standard levels at 70.3% of stations in winter, and at 80% of stations in spring. Investigation statistically significant differences between Nickel concentrations in winter and spring with independent t-test showed that there is no significant difference between the means of the two seasons. Lead concentrations are higher than standard levels all of the stations in winter, and at 96.4% of stations in spring. Investigation statistically significant differences between lead concentrations in winter and spring with independent t-test showed that there is a significant difference between the means of the two seasons.

The average concentrations of Cd, Cr, Cu and Pb in the falling dust of Tehran in both season were above the average concentrations of metals in the earth's crust. Therefore, the increase in heavy metals in the dust fall are probably due to anthropogenic source. But The average concentrations of Nickel Existing in the dust fall in both of the season were lower than the average concentrations of metals in the earth's crust. So its origin is natural.

The regional contamination factor trends of the heavy metals studied in the dust falling in the winter of 2018 from west to east are linear polynomial and increasing. The regional contamination factor trends of the cadmium, chromium and nickel elements from North to South are quadratic polynomial, and about the lead and copper elements are linear polynomial. During this season, the amount of cadmium and lead contaminations factors in the falling dust collected from Tehran are in the category of very high contamination. It is a worrying. At a later stage, there is concern about the amount of copper contamination factor in the dust falling. It is in the category of considerable contamination in most areas of Tehran. At a later stage amount of chromium contamination factor in the dust falling, is in the category of Low contamination in the west of Tehran. It is in the category of moderate contamination in the east of Tehran. The least worrying is about the nickel element. It is in the category of Low contamination (fig 2). In the spring 2018, the regional contamination factor trends of the cadmium, chromium and nickel elements from west to east are quadratic polynomial, and about lead and copper elements are linear polynomial. During this season, the regional contamination factor trends of the cadmium and nickel elements from North to South are quadratic polynomial, and about lead, nickel and chromium elements are linear polynomial. The amount of cadmium and lead contamination factor in the falling dust are in the category of very high contamination in the most areas of Tehran. The amount of chromium and copper contamination factor in the falling dust are in the category of moderate contamination in the most areas of Tehran. The amount of chromium contamination factor in the falling dust is in the category of considerable contamination in the south of Tehran. The amount of nickel contamination factor in the falling dust is in the category of Low contamination (fig 3).

In the reason that Pollution Load Index (PLI) considers the contamination of all heavy metal to be measured, it is a better criterion for complete assessment of polluted areas. According to this index, the regional trend of contamination in winter and spring from west to east is increasing, and all of Tehran' zones are polluted (figs 2.F & 3.F).

In order to investigation ecological risk of Tehran city, the values ER and IR were calculated using equation 3 and 4. The results showed that the amount of chromium, copper and nickel ecological risk in the summer and winter 2018 were in the category of Low in all areas of Tehran. The most worrying is about the cadmium ecological risk, because the amount of cadmium ecological risk in the winter 2018 was in the category of very high, and in the spring 2018 was in the category of high. In the winter the Lead ecological risk values were higher than its amount during spring. The regional ecological risk trend of the lead element from west to east was linear polynomial, and it was increasing. The amount of lead ecological risk in the winter 2018 was in the category of moderation in all areas of Tehran. The amount of lead ecological risk was in the category of considerable in the eastern marginal of Tehran. The amount of lead ecological risk was in the category of low in the west of Tehran. The amount of lead ecological risk was in the category of moderate in the east of Tehran (figs 4 & 5).

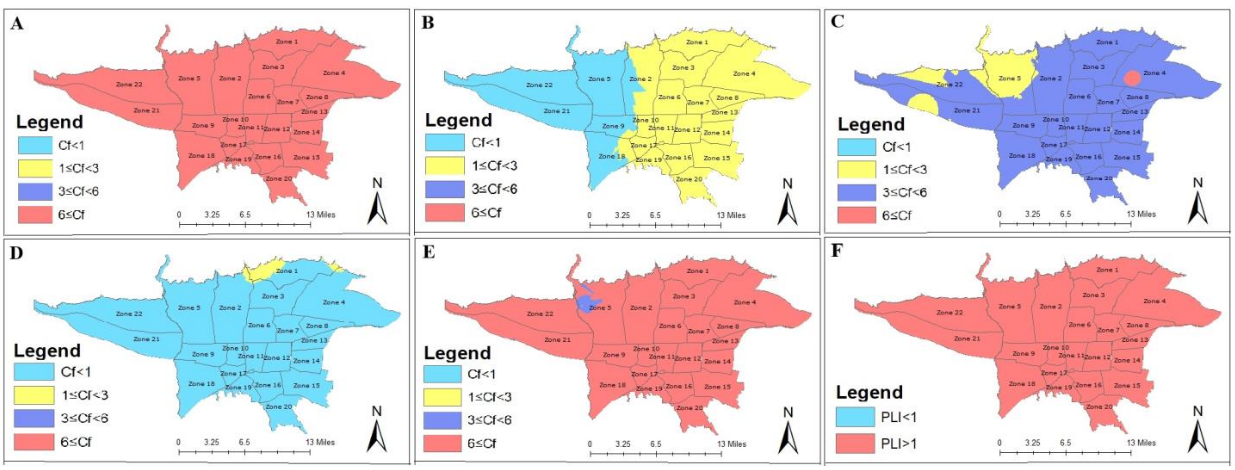

Figure 2. Spatial analysis of (A: Cd, B: Cr, C: Cu, D: Ni, E: Pb) contamination factor and (F: PLI) Pollution Load Index in winter 2018

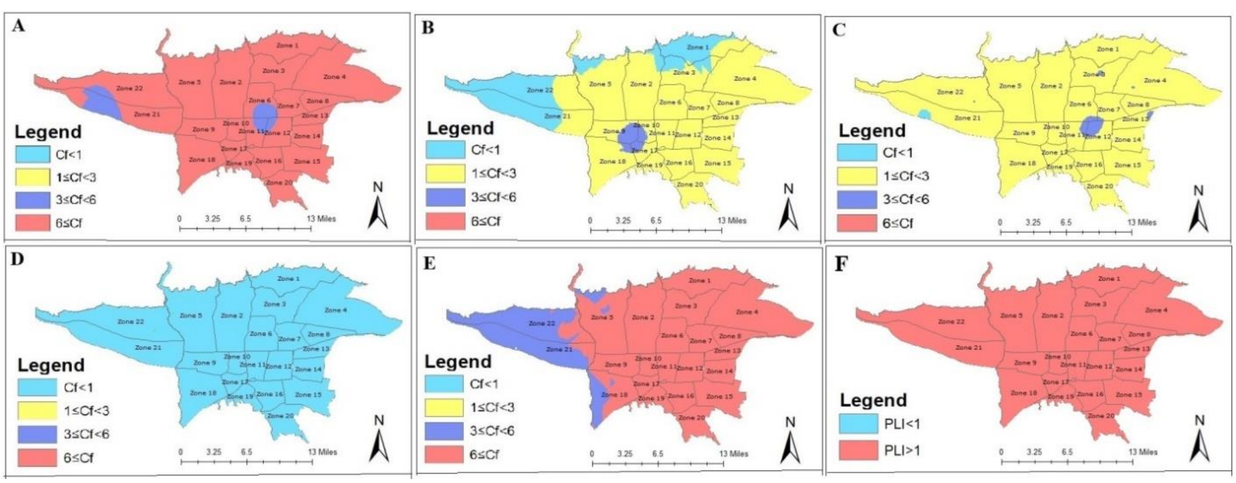

Figure 3. Spatial analysis of (A: Cd, B: Cr, C: Cu, D: Ni, E: Pb) contamination factor and (F: PLI) Pollution Load Index in spring 2018

In the reason that RI considers the ecological risk of all heavy metal to be measured, it is a better criterion for complete assessment of ecological risk areas. The regional RI trends from west to east are linear polynomial, and it is increasing. The regional RI trends from North to South are quadratic polynomial. In the season, the zones located in the east of Tehran, also zone 9 and 10 and parts of the zones 2, 5 and 18 have a very high ecological risk. Other areas have Considerable ecological risk.

In the spring, the regional ecological risk trends from west to east were quadratic polynomial. The regional ecological risk trends from north to south were linear polynomial. on the season, in the most areas of Tehran have considerable ecological risk, and only small parts of some areas have moderate ecological risk.

Due to the toxicity index of cadmium was higher than other studied heavy metals. Also the cadmium concentration in falling dust was high. The cadmium element has a significant effect on the high ecological risk of Tehran. The high concentration of cadmium increased the ecological risk of Tehran (figs 4.F & 5.F).

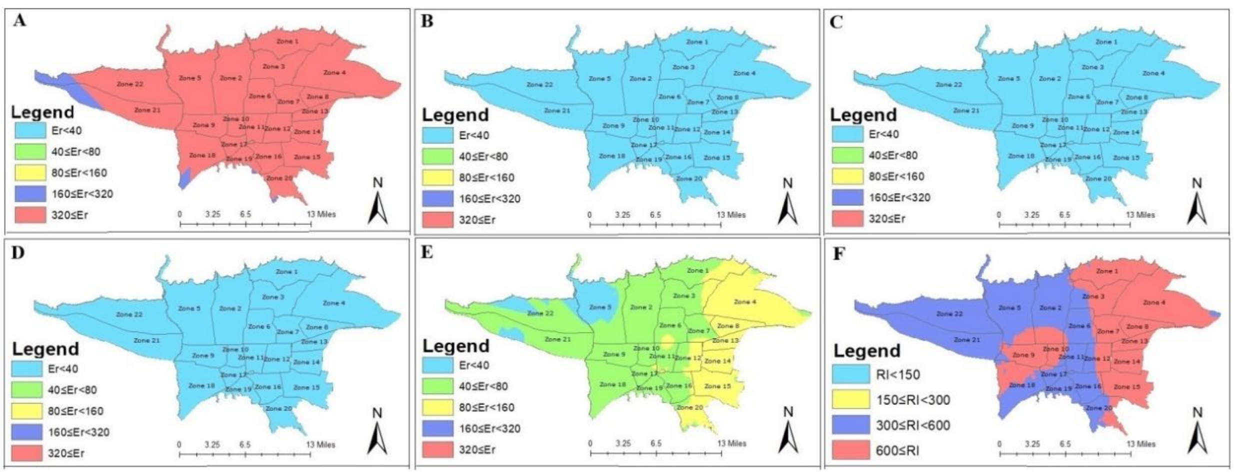

Figure 4. Spatial analysis of (A: Cd, B: Cr, C: Cu, D: Ni, E: Pb) potential ecological risk coefficient and (F: RI) potential toxicity response index in winter 2018

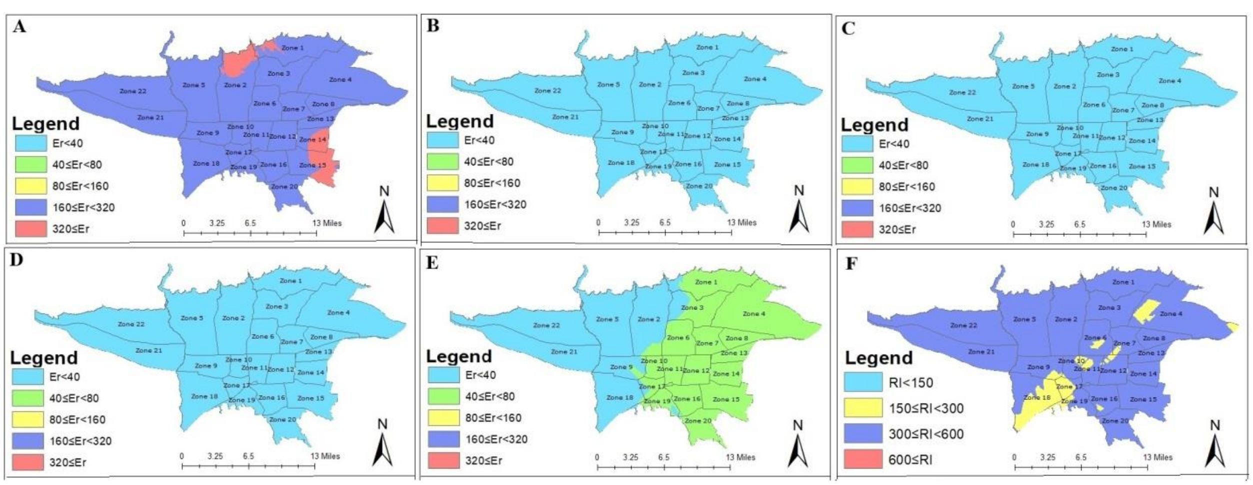

Figure 5. Spatial analysis of (A: Cd, B: Cr, C: Cu, D: Ni, E: Pb) potential ecological risk coefficient and (F: RI) potential toxicity response index in spring 2018

The Tehran wind rose preparation showed that winter and spring 2018 had the highest frequency of winds above 8 (m/s) from the west of Tehran (fig 6). Fieldwork showed that dust particles entered Tehran from sand mines, cement factory and sand processing. The wind carried pollution falling dust into Tehran.

Also, we used HYSPLIT Model in order to dust sources identification and forward trajectory simulation. In this model, the motion of dust particles by using a three dimensional wind vector were designed in the primary location. The extracted points were considered as the center of the crisis. For this purpose, dusting days were studied in the statistical period. The dust trace was implemented in 7 May 2018. The forward trajectory of dust particles at pressure levels with 10, 50, 100 meters in elevation from the sand mine, cement factory and sand processing from the west of Tehran indicates that dust particles arrive from these areas to Tehran (fig 7).

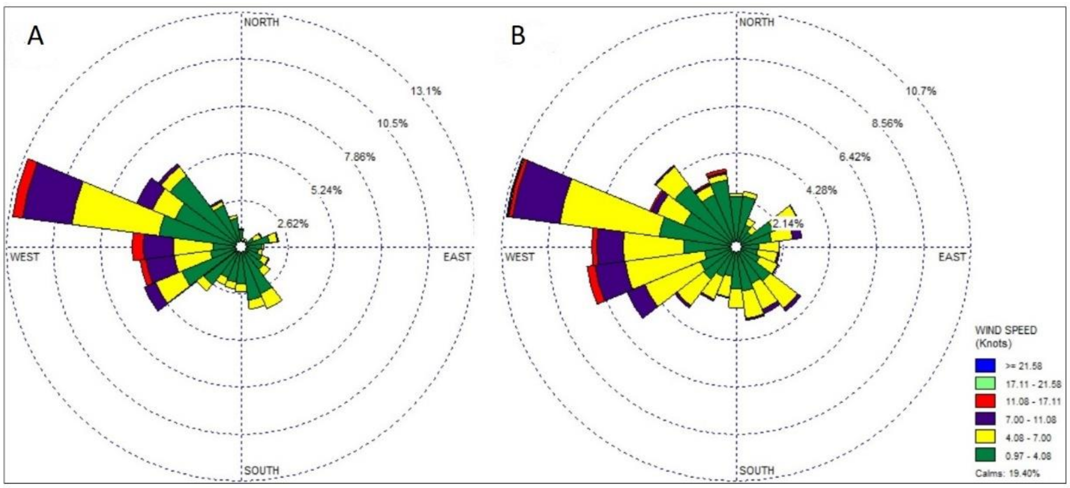

Figure 6. Tehran's wind rose plot, 2018 (A: winter, B: spring)

Figure 7. A: sand mines, B: cement factory and C: sand processing

Discussion

The present study showed that the heavy metals concentrations of dust fall in Tehran were much higher compared with similar studies in other industrialized countries, especially in winter.

There are statistically significant differences with 99% confidence level in concentrations of copper, cadmium and lead between winter and spring. There are no statistically significant differences between average nickel and chromium concentrations of in winter and in spring. The concentrations of Lead, Copper and Cadmium in winter were significantly higher than those in spring. One of the reasons is more stable air and temperature inversion in this season. Also more heating devices which used in winter, causes more heavy metals in season. Mahmoudi and Khademi's research showed that the highest rate of heavy metals in Isfahan's dust fall were in the November and December, because the heating devices which used, and the temperature *inversions* (Mahmoodi and Khademi *et al.,* 2014). Also Saeedi et al. believed that human activities and heating devices are the main sources for heavy metals in the street dust of Tehran (Saeedi *et al.,* 2012).

But the Si-Tir station in the zone 12 in spring has higher pollution and ecological risk than in winter. So that in this season, it has the highest lead and copper concentration among the studied stations. In the Si-Tir Street, street foods have barbecues, and they are causing a lot of smoke. In spring, street foods are more active than in winter, then in spring, the traffic on this street is so heavy. Consequently, in this season, tiny rubber particles and car brake pads cause heavy metal pollution at the station several times more than in winter. Then, the traffic increases concentration of copper and lead around the Si-Tir atmosphere. Mehdipor et al. believed that heavy metals were substantially associated with the traffic level, traffic density of the moving sources, and urbanization in Tehran. The components in car batteries, engine lubricants, and other auto parts (e.g., tires, brake pads, and fuel) contribute to the release of lead, zinc, copper, nickel, cadmium, and manganese (Mehdipor *et al.,* 2020). Also Dehghani et al. and Taghavi et al. Considered that human resources such as heavy traffic, fossil fuels and industries increasing the concentration of heavy metals in Tehran dust (Dehghani *et al.,* 2017., Taghavi *et al.,* 2019). Moreover, Ali Taleshi et al. indicated that the concentrations of cadmium, lead, zinc and chromium in street dust related to human resources and especially road traffic (Ali Taleshi *et al.,* 2020). And Hoseininezhad et al. argued that traffic is one of the important sources of lead, cadmium, nickel and vanadium in Tehran dust (Hoseininezhad *et al.,* 2020).

The results showed that the amount of (Cf), (PLI), (Er) and (RI) for the heavy metals in the dust fall in winter and spring 2018 followed the order of Pb> Cd> Cu> Cr> Ni. The amount of cadmium and lead contaminations and ecological risk in the dust fall were collected from Tehran were in the category of very high contamination. It is a worrying. At a later stage, there is concern about copper pollution and the ecological risk, and to a much lesser extent for chromium . Nickel has the least pollution and ecological risk. Areas located in the east of Tehran have the highest pollution and ecological risk in terms of cadmium, copper, nickel and lead. Mazloumi et al. indicated that highest concentration of heavy metals in pm4 were found in the east of Tehran. (Mazloumi *et al.,* 2017). Among the reasons for this, we can mention the faster winds in the western regions of Tehran (Figure 6) and also the topographic pattern of Tehran (Figure 7). Also Namazei et al. argued that the average of heavy metals concentration in Lenjanat of Isfahan, Iran has significantly different from each other in most seasons. These differences have been related to various factors such as wind speed, change the direction of the wind, the amount and type of activity of mines and industries, and amount of soil humidity and air humidity (Namazi *et al.,* 2015). Ekhlaspour et al.

argued that wind speed and wind direction affect the distribution of heavy metals pollution (Ekhlaspour *et al.,* 2019).

The most of the chromium contamination is in the central areas into south of Tehran. The chromium has a different source of diffusion than other heavy elements studied. Chromium does not play an important role in traffic dust (Salmanzadeh *et al.,* 2012). Ali Taleshi et al. considered that the chromium in Tehran's air originating from human activities (Ali Taleshi *et al.,* 2020). According to the list of toxic substances in ATSDR[7], chromium emissions are primarily due to combustion processes, metal industries and cement-producing. Investigate the forward tracking of particles (Figure 7) and Wind rose Tehran (Figure 6) showed that one of the reasons can be attributed to the sand mines located in the west of Tehran. In spring, when the weather is more unstable, more dust enters these areas. And heavy metals that stick to dust particles are more likely to enter these areas. So in the spring the chromium pollution is more worrying. Dehghani et al. argued that industries located in the southwest of Tehran causes street dust pollution with heavy metals. Traffic and heat sources are the main sources of heavy elements in the dust fall of Tehran (Dehghani *et al.,* 2017). Also Samani et al. reported that due to the westward winds of Tehran and the establishment of an important part of industries in the west of the city, most of the industrial pollution driven from west to east (Samani *et al.,* 2020).

Conclusion

Heavy metals in dust fall are an important component of urban environmental pollution. Today, the harmful effects of these metals on human health have been proven. Due to the high population of the metropolis of Tehran, the results of this research are very important for developing management approaches to create a healthier environment. The results of the present study confirmed the amount of cadmium and lead contaminations and ecological risk in the falling dust were collected from Tehran were in the category of very high contamination. It is a worrying. Also, areas located in the east of Tehran have the highest pollution and ecological risk in terms of cadmium, copper, nickel and lead. Most of the chromium contamination is in the central areas into south of Tehran. Traffic and heat sources are the main sources of heavy metals in the dust fall of Tehran. Also Tehran's prevailing wind direction and Tehran's topographic pattern, mines, factories and industries located in the west and southwest of Tehran have main role in polluting Tehran's falling dust with heavy elements. According to the results of this study, it is suggested the expansion of public transport, Enhance the quality and spreading the culture of using it (especially the subway), especially in the eastern half of Tehran, and to create more and higher vegetation in the western and southern suburbs of Tehran, so for pollution management and control.

References

Aguilera, A., C. Armendariz ., P. Quintana., F. Garcia-Oliva ., F. Bautista , 2019. Influence of land use and road type on the elemental composition of urban dust in a Mexican metropolitan area. Environmental Studies, 28;1535–1547.

Apeagyei, E., M.S. Bank., J.D. Spengler, 2011.Distribution of heavy metals in road dust along an urban-rural gradient in Massachusetts. Atmospheric Environment, 45;2310-2323.

Ali, H., E. Khan., I. Ilah , 2019. Contamination Evaluation and Source Identification of Heavy Metals in the

[7] ATSDR: Agency for Toxic Substances and Disease Registry

Sediments from the Lishui River Watershed, Southern China. Chemistry, 4; 1-14.

Ali-Taleshi, M.S., M. Moeinaddini., S. Feiznia., S. Squizzato , 2018. Heavy Metal Pollution in Street Dust from Tehran in 2018: Metal Richness and Degree of Contamination Assessment. Environmental Health Enginering, 7 ; 179-194.

Aili, A, H. Xu., T. Kasim., A. Abulikemu , 2021. Origin and Transport Pathway of Dust Storm and Its Contribution to Particulate Air Pollution in Northeast Edge of Taklimakan Desert, China. Atmosphere 12;1-15.

Arsalani, F., 2019. Analysis of Tehran city falling dust and study of it's sources. PhD Thesis, Department of Natural Geography , Kharazmi University, Tehran, Iran.

Arsalani, F, B. Alijani., M. Akbari., Sh. Mohammadkhan, 2019. measuring the rate of dust falling and its spatial analysis in 22 areas of Tehran. Physical Geography Research Quarterly Journal, 51; 633-649. Arsalani, F, B, Alijani ., M. Akbari., Sh. Mohammadkhan , 2020. Investigate of heavy metals (Cd, Cr, Cu, Ni, Pb) Existing in falling dust of Tehran. Reseaches in Earth Sciences Journal, 11; 15-36.

Ashrafi,KH., M. Shafiepour-Motlagh ., A. Aslemand., S. Ghader , 2014. Dust storm simulation over Iran using HYSPLIT. Environ Health Science Engineering.,12; 2-9.

Azimzadeh, HR., RA. Fallahzadeh., MT. Ghaneian., SA. Almodaresi., H. Eslami., M. Taghavi, 2017. Investigation of chemical characteristics and spatiotemporal quantitative changes of dust fall using GIS and RS technologies; a case study, Yazd city, central plateau of Iran. Environmental Health Engineering and Management Journal, 4; 45–53.

Behravesh, F., MH. Mahmudy Gharaie., F. Ghassemzadeh., S. Avaz Moghaddam ,2015. Determination of heavy metals pollution in traffic dust of mashhad city, and its origin by using ‘‘selectiv sequential extraction’’(sse) Procedure. Engineering and Environmental Geology,24;141-150.

Berivan, HM, 2021. Measurement of Fall Rate and Analysis of Atmospheric Falling Dust in Duhok Governorate of Iraq by Using Atomic Absorption Spectrometry and X-ray Diffraction. Journal of Physics: Conference Series; 2nd Annual International Conference on Information and Sciences (AiCIS) 2020.

Budai, P., A. Clement, 2018. Spatial distribution patterns of four traffic-emitted heavy metals in urban road dust and the resuspension of brake-emitted particles: findings of a field study. Transportation Research Part D: Transport and Environment, 62; 179–185.

Cao, H., F. Amiraslani ., J. Liu., Z. Zhou, 2015. Identification of dust storm source areas in West Asia using multiple environmental datasets. Science of the Total Environment, 502; 224–235.

Charlesworth, S, M. Everett., R. McCarthy., A. Ordonez., E. de Miguel, 2003. A comparative study of heavy metal concentration and distribution in deposited street dusts in a large and a small urban area: Birmingham and Coventry, West Midlands, UK. Environment International, 29; 563–573.

Chen, B, AF. Stein., P. Guerrero Maldonado., AM. Sanchez de la Campa., YG. Castanedo., N. Castell., De la R. Jesus, 2013. Size distribution and concentrations of heavy metals in atmospheric aerosols originating from industrial emissions as predicted by the HYSPLIT model. Atmospheric Environment, 71; 234-244.

Christoforidis, A., N. Stamatis, 2009. Heavy metal contamination in street dust and roadside soil along the major national road in Kavala's region, Greece. Geoderma, 151; 257–263.

Csavina, J., J. Field., MP. Taylor., S. Gao., A. Landazuri., EA. Betterton., EA. Saez, 2012. A review on the importance of metals and metalloids in atmospheric dust and aerosol from mining operations. Science of the Total Environment, 433; 58–73.

Dehghani, S, F. Moore., B. Keshavarzi., AH. Beverley , 2017. Health risk implications of potentially toxic metals in street dust and surface soil of Tehran, Iran. Ecotoxicology and Environmental Safety, 136; 92-103.

de Miguel, E., JF. Llamas., E. Chacon., T. Berg., S. Larssen., O. Royset., M. Vadset, 1997. Origin and patterns of distribution of trace elements in street dust: unleaded petrol and urban lead. Atmospheric Environment, 31; 2733-2740.

El-Sherbin, M., A. Ismail., M. EL-Hefnawy, 2019. A preliminary assessment of potential ecological risk and soil contamination by heavy metals around a cement factory, western Saudi Arabia. Open Chemistry, 17; 671–684.

El-Araby, EH., M. Abd El-Wahab., HM. Diab., TM. El-Desouky., M. Mohsen, 2011. Assessment of Atmospheric heavy metal deposition in North Egypt aerosols using neutron activation analysis and optical emission inductively coupled plasma. Applied Radiation and Isotopes, 69; 1506-1511.

Ekhlaspour, A., B. Khalilimoghadam., M. Soleimani, 2019. Assessing heavy metal concentration in the soil and plants of surroundings Khuzestan steel factory. Iranian journal of soil and water research, 50; 603-613.

Gurumoorthi, K., R. Venkatachalapathy, 2016. Spatial and seasonal trend of trace metals and ecological risk assessment along Kanyakumari coastal sediments, southern India. Pollution, 2; 269-287.

Hai, CX., CS. Yuan., GT. Liu., XJ. Li., F. Zhang., XJ. Zhang, 2008. Research on the Components of Dust Fall in Hohhot in Comparison with Surface Soil Components in Different Lands of Inner Mongolia Plateau. Water Air and Soil Pollution, 190; 27-34·

Ha, R., A. Baatar., Y. Yu, 2017. Identification of atmospheric transport and dispersion of Asian dust storms. Natural Hazards and Earth System Science, 17; 1425–1435.

Harb, MK., M. Ebqa’ai., A. Al-rashidi., BH. Alaziqi., MS. Al Rashdi., B. Ibrahim, 2015. Investigation of selected heavy metals in street and house dust from Al-Qunfudah, Kingdom of Saudi Arabia. Environmental Earth Sciences, 74; 1755–1763.

Hakanson L. 1980. An ecological risk index for aquatic pollution control - A sedimentological approach. Water Research;14(8):975-1001.

Harikumar, P., U. Nasir., MM. Rahman, 2009. Distribution of heavy metals in the core sediments of a tropical wetland system. Environmental Science and Technology , 6; 225–232.

Hoseininezhad, F., A. Behbahaninia., N. Mansour, 2020. Determination of heavy metal concentrations (vanadium, lead, nickel, cadmium (in dust and comparison with pollution index and Geo accumulation index (Case Study: Downtown of Tehran). Environmental Sciences Studies, 4; 1943-1948.

Hu, X., Y. Zhang., J. Lou., T. Wang., H. Lian., Z. Ding, 2011. Bioaccessibility and health risk of arsenic, mercury and other metals in urban street dusts from a mega-city, Nanjing, China. Environmental Pollution, 159; 1215-122.

Jia, Q., Y. Huang, 2008. Coarse dust around mining areas: a study of available dust collectors and their efficiency. MASTER’S THESIS. Lulea University of Technology, department of Civil and Environmental Engineering, Division of soil Mechanics and Foundation Engineering.

Kamani, H., AH. Mahvi., M. Seyedsalehi., J. Jaafari., M. Hoseini., GH. Safari., A. Dalvand ., H. Aslani., N. Mirzaei., SD. Ashrafi, 2017. Contamination and ecological risk assessment of heavy metals in street dust of Tehran, Iran. Environmental Science and Technology, 14; 2675-2682.

Kartal, S., Z. Aydin., S. Takalioglu, 2006. Fractionation of metals in street sediment samples by using the BCR sequential extraction procedure and multivariate statistical elucidation of the data. Hazardous Materials, 132; 80-89.

Khuzestani, RB., B. Souri B, 2013. Evaluation of heavy metal contamination hazards in nuisance dust particles, in Kurdistan Province, western Iran. Environmental Sciences, 25; 1346-1354.

Khalilimoghadam, B., S. Ataollahsiadat., A. Yusefi., K. Negaresh, 2021. Atmospheric particle adsorption rates of plants in an industrial city of southwest Iran. Aeolian Research, 53; 1346-1354.

Kumar, Sh., RM. Agrawal., FM. Marshall, 2008. Atmospheric deposition of heavy metals (Cu, Zn, Cd and Pb) in Varanasi City, India. Environmental Monitoring Assessment, 142; 269-278.

Kumari, Sh., MK. Jain., SP. Elumalai , 2021. Assessment of Pollution and Health Risks of Heavy Metals in Particulate Matter and Road Dust Along the Road Network of Dhanbad, India .Health and Pollution, 11; 4-12.

Leung Anna, OW., S. Duzgoren-Aydin Nurdan., KC. Cheung., H. Wong Ming, 2009. Heavy Metals Concentrations of Surface Dust from e-Waste Recycling and Its Human Health Implications in Southeast China. Environmental science & technology, 42; 2674-2680.

Mahmoodi, Z., H. Khademi, 2014. Concentration of selected heavy metals in atmospheric dust of Isfahan and neighboring metropolitan areas. JWSS-Isfahan university of technology, 18; 243-255.

Mazloomi, S., A. Esmaeili – Sari., N. Bahramifar., M. Moeinaddini, 2017. Assessment of the metals and metalloids level in street dust of the east and west of Tehran. Health and Environment, 10; 281-292.

Mehdipour, A., M. Zaeimdar., MS. Sekhavatjou., SA. Jozi , 2020. Heavy metal concentrations in the outdoor and indoor air of high traffic areas in Tehran, Iran. Advances Environmental Health Research, 8; 25-37.

Modaihsh, AS., MO. Mahjoub , 2013. Falling Dust Characteristics in Riyadh City, Saudi Arabia During Winter Months. APCBEE Procedia, 5; 50 – 58.

Namazi, N., MH. Salehi., J. Mohammadi, 2015. Spatial and temporal variability of some of heavy metals in aerosols of Lenjanat region, Esfahan. Water and Soil, 29; 114-125.

Niencheski, LFH., B. Baraj ., RG. France., N. Mirlean, 2002. Lithium as a normalizer for the assessment of anthropogenic metal contamination of sediments of the southern area of Patos Lagoon. Aquatic Ecosystem Health & Management, 5; 473-483.

Ramlan, MN., MA. Badri , 1989. Heavy metals in tropical city street dust and road side soils: a case of Kuala lumpur, Malaysia. Environmental Technology Letters, 10; 435-444.

Rasmussen, PE., KS. Subramanian., BJ. Jessiman , 2001. A multi-element profile of house dust in relation to exterior dust and soils in the city of Ottawa, Canada. Science of the Total Environment, 267; 125-140.

Salmanzadeh, M., M. Saeedi ., GH. Nabi Bidhendi,2012. Heavy metals pollution in street dusts of Tehran and their ecological risk assessment. Environmental Studies, 38; 9-18.

Sami, M., A. Waseem ., S. Akbar, 2006. Quantitative estimation of dust fall and smoke particles in Quetta Valley. Zhejiang University Science, 7; 542–547.

Saeedi, M., L. Li., M. Salmanzadeh, 2012. Heavy metals and polycyclic aromatic hydrocarbons: pollution and ecological risk assessment in street dust of Tehran. Hazardous Materials, 227; 9-17.

Samani, M., A, Golchin .,H. Alikhani .,A. Baybordi, 2020. Health risk assessment of Pb in atmospheric dust in Tehran city in different seasons. School of public health and institute of public health research, 18 ; 289-306.

Schwar, MJR., JS. Moorcroft., DPH. Laxen, M. Thompson., C. Armorgie, 1988. Baseline metal in dust concentrations in Greater London. The Science of the Total Environment, 68; 25-43.

Shi, G., Z. Chen ., C. Bi ., Y. Li , 2010. Comprehensive assessment of toxic metals in urban and suburban street deposited sediments (SDSs) in the biggest metropolitan area of China. Environmental Pollution, 158; 694-703.

Sow, M., D. Goossens ., JL. Rajot 2006. Calibration of the MDCO dust collector and of four versions of the inverted Frisbee dust deposition sampler. Geomorphology, 82; 360-375.

Taghavi, SN., H. Kamani ., MH. Dehghani., R. Nabizadeh ., N. Afshari ., AH. Mahvi , 2019. Assessment of Heavy Metals in Street Dusts of Tehran Using Enrichment Factor and Geo-Accumulation Index. Health Scope, 8; 1-9.

Wang, X., Z. Dong ., C. Zhang ., G. Qian ., W. Luo , 2009. Characterzation of the composition of dust fallout and identification of dust sources in arid and semiarid North Chiana. Geomorphology, 112; 144-157.

Wang, J., X. Zhang ., Q. Yang ., K. Zhang ., Y. Zheng ., G. Zhou, 2018. Pollution characteristics of atmospheric dust fall and heavy metals in a typical inland heavy industry city in China. Environmental Sciences , 30; 283-291.

Wei, B., F. Jiang ., X. Li ., S. Mu , 2009. Spatial distribution and contamination assessment of heavy metals in urban road dusts from Urumqi, NW China. Microchemical Journal, 93; 147-52.

Yang, Sh., J. Liu ., X. Bi ., Y. Ning ., Sh. Qiao., Q. Yu ., J. Zhang , 2020. Risks related to heavy metal pollution in urban construction dust fall of fast-developing Chinese cities. Ecotoxicology and Environmental Safety, 197; 1-14.
Yi, Y., Z. Yang ., S. Zhang , 2011. Ecological risk assessment of heavy metals in sediment and human health risk assessment of heavy metals in fishes in the middle and lower reaches of the Yangtze River basin. Environmental Pollution, 159; 2575 – 2585.
Zarasavandi, A., EJM. Crrenzea., F. Moore ., F. Rastmanesh F, 2011. Spatio – temporal occurrences and mineralogical – geochemical characteristics of airborne dusts in Khuzestan Province (southwestern Iran). Geochemical Exploration, 111; 138-151.
Zheng, N., J. Liu ., Q. Wang ., Z. Liang , 2010. Health risk assessment of heavy metal exposure to street dust in the zinc smelting district, Northeast of China. Science of the Total Environment, 408; 726– 733.
Zhou, S., R. Deng ., A. Hursthouse , 2019. Risk Assessment of Potentially Toxic Elements Pollution from Mineral Processing Steps at Xikuangshan Antimony Plant, Hunan, China. Processes, 8; 1-12.