Article

Assessment of heavy metal contamination in urban dusts and road dusts of Tehran

Movafagh Afsaneh[1], **Mansouri Nabiollah**[1], **Moattar Faramarz**[1], **Vafaeinejad AlirezaR**[2]
[1]Department of National resource and Environment , Science and Research Branch, Islamic Azad University,Tehran, Iran
[2]Faculty of Civil, Water and Environmental Engineering, Shahid Beheshti University, Tehran, Iran
Email: nmansourin@gmail.com

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Abstract
This study was carried out to assess and compare the status of heavy metals pollution (lead, chrome, cadmium, nickel and zinc) present in PM_{10} particles in the road and city of Tehran. For this purpose, in August 2014 from the zone 22 of Tehran city 14 samples and from the road, i.e. Hemmat expressway 28 samples were collected with the help of the system. The sampling filters were digested using the concentrated nitric acid and the metals rate of heavy metals (lead, chrome, cadmium, nickel and zinc) present in the samples was determined via flame atomic absorption system. The average concentration of metals; lead, chrome, nickel, zinc and cadmium in the city PM_{10} particles were 0.115, 0.020, 0.019, 1.144, 0.004 μg/m^3 respectively. In case of heavy metals in PM_{10} particles, the average heavy metals concentration, i.e., lead, chrome, nickel, zinc and cadmium were 0.0943, 0.011, 0.0135, 0.0567, 0.003 μg/m^3 respectively. In both the cases, nickel value was higher than the standard. It can be safely mentioned that with the increase of distance from the road the concentration of pollutants reduces. The spatial distribution map of these metals was prepared with Arc GIS software. Even the statistical and clustering analysis was calculated for sourcing of metals in the two conditions. The results showed that the majority of the metals have a traffic source and only zinc that has the highest rate in the city, besides has the other varied source. This led to analysis of carcinogenesis and non-carcinogenesis risk of heavy metals in PM_{10} particles of city and the road. The results showed that as far as carcinogenesis and non-carcinogenesis risk is concerned, there is nil anxiety in the city and the road.

Keywords air pollution; heavy metal; risk assessment; human health.

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1 Introduction
The environmental pollution via heavy metals has converted into a global issue due to side effects of these poisonous materials on the viable organisms. The heavy metals due to high stability in the environment and accumulation in the natural reservoirs collection and eventually entrance to the food cycle are encountered

with a high ecological importance. The heavy metals via coupling to the dust particles are capable to disperse in the larger scale. The humans via consumption, respiration and dermal absorption of the dust particles are influenced by heavy metals associated with the dust (Sayadi and Torabi, 2007; Su et al., 2014). A large number of studies have been reported on the heavy metals concentration in the dust particles. The major section of these studies has been carried out in the developed countries and a lesser number in developing countries. Munir and Shaheen investigated the annual and seasonal changes of metals in the suspended particles of Islamabad, Pakistan and showed that the metals have the following reducing trend (Munir and Shaheen, 2008): Fe > Zn > K > Mg > Cu > Sb >Pb>Sr>Mn> Co >Ni > Cr > Li > Cd ≈ Ag. Manjuet al., assessed the seasonal changes of metals in suspended particles of the Kota industrial city, India and demonstrated that lead, zinc, copper and cadmium have a human origin wherein the relative frequency of these metals is higher in winters and lower in summers (Manju et al., 2016). Lu et al., also assessed the metals pollution and health risk in the dust of Nursing Institute in Xi'an, China and reported that there is no danger from the viewpoint of cancerous or non-cancerous diseases (Lu et al., 2014). Leili et al. investigated the suspended particles and heavy metals in the centre of Tehran and in the range of Tehran University and reported that the metals were below the standard level (Leiliet al., 2008). Sayadi et al. also assessed impact of land use on the distribution of toxic metals in surface soils in Birjand city, Iran and reported that the soil is contaminating and in the near future the concentration of toxic metal will be beyond the threshold values (Sayadi et al., 2017). Kumar etal investigated heavy metal speciation of soil and *Calotropis procera* from thermal power plant area and showed presence of these heavy metals/metalloids can be attributed to the coal used for combustion from which they are volatised and after condensation are associated to the fly ass (Kumar Prajapati and Meravi, 2014). Today, the need to study the specifications of particles and their dispersal mode along with the determination of production source of these particles in different cities has become the essential priorities of the cities pollution control programs. Overall, the aim of this study was 1- Assessment and determination of the metals concentration viz. cadmium, lead, nickel, chrome and zinc in the urban and road PM10 particles, 2- Determination of spatial distribution and as well specification of the origin of these metals in the urban and road PM10 particles and 3- Health risk evaluation of these metals in the city and road on the two groups viz. children and adults viaingestion, respiration and dermal absorption.

2 Study area and Methodology

2.1 Study site

Tehran, the capital city of Iran and largest city and urban area of Iran, is situated 1050 m above sea level (Latitude 35°34 N and Longitude51°36 E). Population of Tehran is around 9 million and 16 million in the wider metropolitan area. Shahid Hemmat Expressway is one of the Tehran expressways. This expressway is the main connecting route of Tehran's east to west and west to east.

2.2 Data collection

Seven sampling locations were selected for dust urban. For urban area sampling locations were west of Tehran (Yas town, Banafsheh, Sarvestan town , Qaem, Shaghayegh, Nemouneh Sepah town, Shahidbagheri town) during the present study. TSP samples were collected on cellulose using SKC pump. The site of sampling stations in the city and the road is specified in the Fig. 1. For suspended particles in the road, the sampling was taken from the two routes *viz.* east to west of Hemmat Expressway and as well west to east (the to and fro route) from the intersection of Azadegan Boulevard and Hemmat Highway to Pajoohesh Boulevard. The distance of stations from one another was 1 kilometer. In Fig. 1 using GIS the site of stations has been specified. The traffic density in this road is around 71404 vehicles/ day being constituted of 95.57% cars, 1.22% motorcycles, and 2.21% tracks.

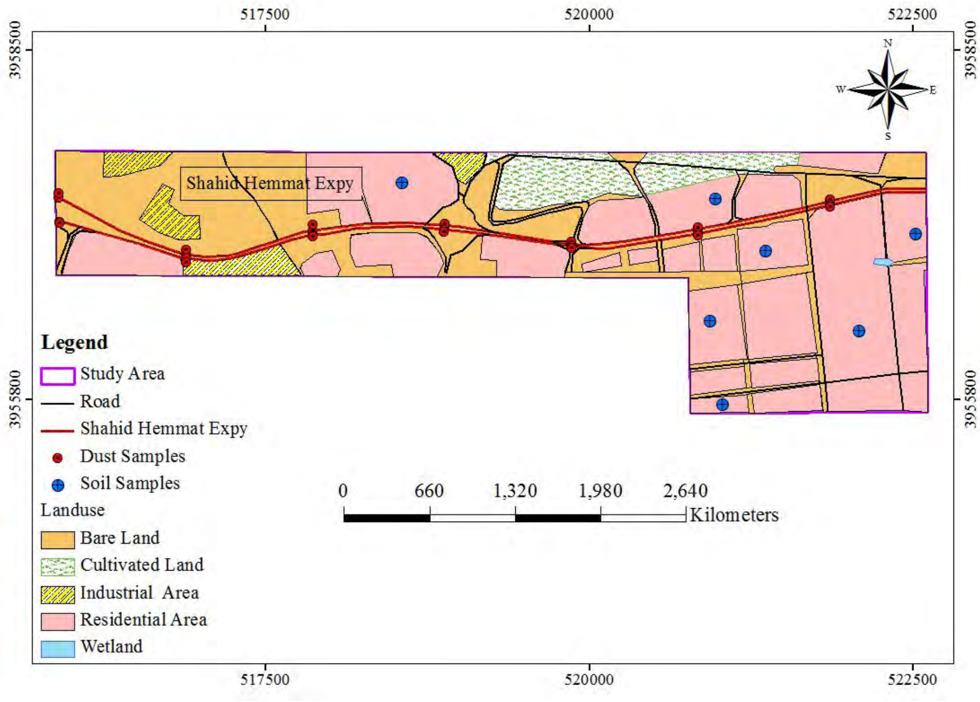

Fig. 1 Sampling stations site of urban and road PM_{10} particles.

2.3 Extraction procedure and analysis

Filters digested with nitric acid (Merck 65%) and perchloric acid (Merck 70%) mixture (10:1, v/v) (NIOSH Method-7300 1984). The digested solution was filtered with washing by doubly distilled water and refrigerated in pre-cleaned strong polyethylene bottle until analysed (Gonzalez et al., 1997). Metals were detected by Atomic Absorption Spectrophotometer (Shimadzu, model AA-670, Japan). The detection limits of the spectrometer were 0.0150 mg/mL^{-1} for Cd, 0.1250 mg/mL^{-1} for Pb, 0.0075 mg/mL^{-1} for Zn and 0.0500 mg/mL^{-1} for Ni.

2.4 Health risk assessment model

In this model, pathways of pollutants attached to surface dusts entering a human body were: hand-to-mouth ingestion, dermal absorption and mouth and nose inhalation. The dose received via each of the three paths was calculated using following Eqs. (USEPA 1989, 1996)

$$D_{inh} = \frac{C \times InhR \times EF \times ED}{PEF \times BW \times AT},\ D_{ing} = \frac{C \times IngR \times EF \times ED}{BW \times AT} \times 10^{-6},\ D_{dermal} = \frac{C \times SL \times SA \times ABS \times EF \times ED}{BW \times AT} \times 10^{-6}$$

$$LADD = \frac{C \times EF}{AT \times PEF} \times \left(\frac{InhR_{child} \times ED_{child}}{BW_{child}} + \frac{InhR_{adult} \times ED_{adult}}{BW_{adult}} \right)$$

Where, D_{ing} is the daily dose via hand-to-mouth ingestion of substrate particles; D_{inh} is the daily dose via inhalation of re-suspended particles through mouth and nose; D_{dermal} is the daily dose via dermal absorption of trace elements in particles adhered to exposed skin; LADD is the lifetime average daily dose for cancer elements via inhalation exposure route. The meaning and corresponding unit values of other parameters`are indicated in Table 1. The non-carcinogenic risks for individual metals were calculated using the following equation:

$$HI = \sum HQ, HQ = D/RfD$$

Where, HI is hazard index, HQ is hazard quotient, D is average daily dose, and R_fD is specific reference dose. The particular reference dose ($mg.kg^{-1}.day^{-1}$) was an estimate of maximum permissible risk of a human population through daily exposure during a lifetime. If HQ or HI exceeds one, then there is a chance of occurrence of non-carcinogenic effects, with a probability which tends to increase as the value of HQ or HI increases (USEPA2001).

The potential was calculated using the following equation:

CR= D×SF

Where, SF isthe corresponding slope factor.

In general, the USEPA recommends that if the value of CR is above (10^{-4}-10^{-6}), then the exposed population is said to be unsafe.

Table 1 Meaning and corresponding unit values of parameters.

Parameter	Meaning and Unit Values	Values	
		Child	Adult
C	Exposure-point concentration, mg/kg	-	-
IngR	Ingestion rate, mg/d	200	100
InhR	Inhalation rate, m^3/d	7.6	20
PEF	Particle emission factor, m^3/kg	1.36×10^9	1.36×10^9
SA	Exposure skin area, cm^2	2800	5700
SL	Skin adherence factor, $mg/(cm^2h)$	0.2	0.7
ABS	Dermal absorpton factor, unitless	0.001	0.001
ED	Exposure duration, y	6	24
EF	Exposure frequency, d/y	180	180
BW	Average body weight, kg	15	70
AT	Average time, d	ED×365(for non-carcinogens) 70×365(for carcinogens)	

The statistical analysis was carried out using SPSS software. For spatial distribution modeling, the Arc GIS 9.3 software was used.

3 Results and Discussion

3.1 The statistical analysis of heavy metals in PM_{10} particles in the city

As shown in Table 2, the average concentration of metals; zinc, chrome, nickel, lead and cadmium were 0.115, 0.020, 0.019, 1.114 and 0.004 µg/m^3 respectively. The highest concentration average pertained to metal zinc *viz*. 114 µg/m^3. As a general rule it can be said that heavy metals have the following reducing trend: Zn>Pb>Cr >Ni >Cd.

The comparison of metals average with the values declared *via* WHO and USEPA demonstrated that, except nickel the values of metals were lower than the standard. Averagely, the level of nickel was 50 times (0.191 $\mu g/m^3$) more than the WHO standard and 79 times more than the USEPA standard. Monir and associates also obtained similar results (Monir et al., 2008). The average concentration value of the metals; lead, chrome, nickel, zinc and cadmium in the PM_{10} particles in the city was 0.115, 0.020, 0.019, 1.144 $\mu g/m^3$ respectively. The maximal standard deviation pertained to zinc and the maximal extension pertained to chrome. The data demonstrated the abnormal distribution of metals in the city dust particles.

Table 2 The statistical analysis of heavy metals in Pm_{10} particles in the city.

	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
pb	0.043	0.211	0.115	0.069	0.474	-2.034
Cr	0.013	0.036	0.020	0.009	1.100	-0.419
Ni	0.010	0.026	0.019	0.006	-0.095	-1.805
zn	0.196	2.185	1.144	0.749	-0.180	-1.105
cd	0.001	0.007	0.004	0.002	-0.850	-0.918

Table 3 Pearson correlation coefficient for the suspended particles in the city.

Heavy metals	Pb	Cr	Ni	Zn	Cd
Pb	1				
Cr	0.934**	1			
Ni	0.915**	0.754	1		
Zn	0.919**	0.875**	0.923**	1	
Cd	0.783*	0.683	0.906**	0.948**	1

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed). The Pearson’s correlation coefficient (r) was calculatedntration in order to predict thepossibility of a common source of particulate matter.

As demonstrated in Table 3, in urban dust a significant positive correlation exists between lead and chrome, nickel and zinc in the 1 percent level and between lead and cadmium at the 5 percent level. Besides, between zinc and chrome, nickel and cadmium as well nickel and cadmium a positive correlation at the 1 percent level exists. Monir et al. showed that even a correlation exists between lead and cadmium (Monir et al., 2008).

In the clustering analysis of urban dust the metals are divided into two clusters:

Cluster number 1: Chrome, nickel, cadmium and lead

Cluster number 2: lead

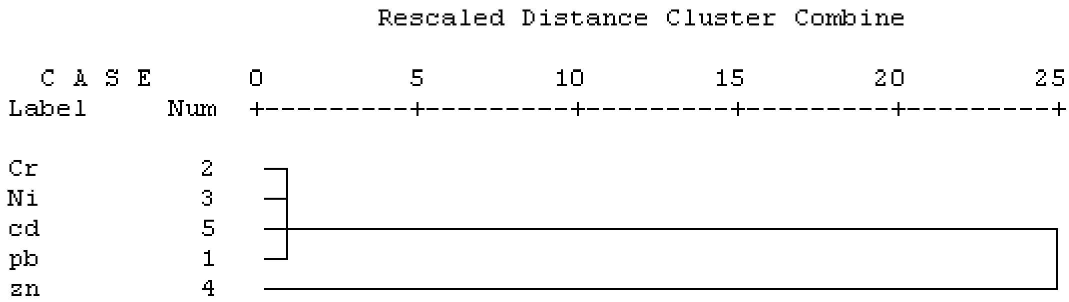

Fig. 2 In the clustering analysis of urban dust.

The clustering analysis is adopted for grouping of the metals that have many similarities and a common origin (Vojtesek et al. 2009; Gatari et al. 2006; Weinbruch, 2004; Dušan et al., 2014; Pant et al., 2013; Thorpe et al,. 2008) showed the heavy metals resources in the suspended particles as follows

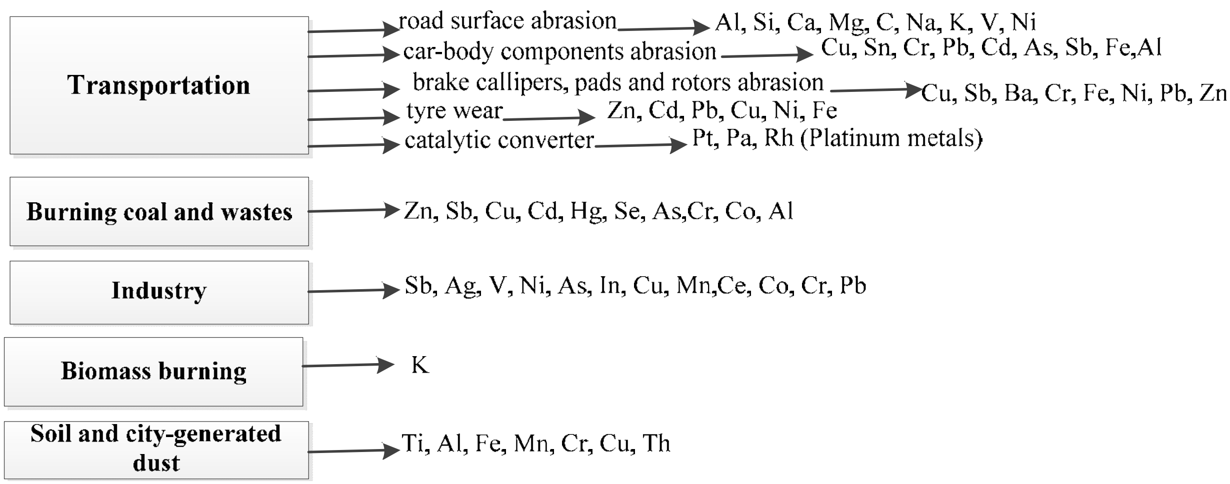

Fig. 3 Resources of heavy metals in the suspended particles.

As specified in the diagram and as well in metals clustering analysis, the entire case study metals *viz.* chrome, nickel, cadmium, lead and zinc have a common origin and are consequent of traffic and transportation, except zinc that in addition to traffic origin has another origin too.

3.2 The spatial distribution of heavy metals in urban PM_{10} particles

Fig. 4 demonstrates the spatial distribution of heavy metals. As it is specified, lead and zinc in relation to the other metals have a significant concentration and as we get closer to the road, the concentration of pollutants increases and with the increase of distance from the road the concentration of pollutants reduces. The highest concentration of pollutants was in the station 1 i.e. Yatown which is adjacent of two high-traffic and busy expressways *viz.* Hemmat and Tehran- Karaj Expressways and the lowest concentration was observed in the station 6 i.e. Shahid Bagheri that has a significant distance from the Hemmat Expressway and encounters a lower traffic rate. Wawer et al., in the assessment of pollutants consequent to traffic in different European and Asian countries showed that the level of lead, zinc, cadmium and copper increases with traffic increase (Wawer et al., 2015).

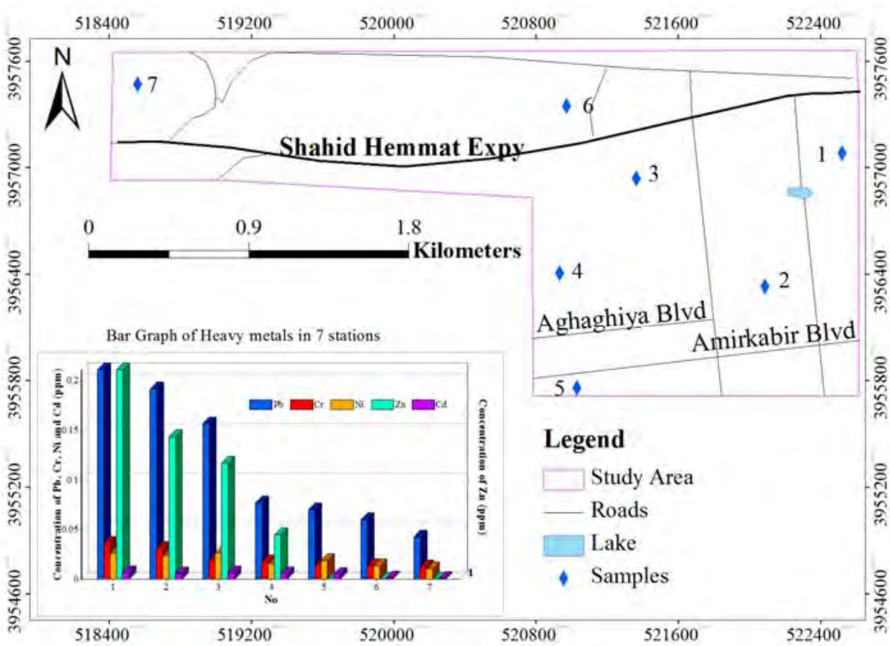

Fig. 4 The spatial distribution of heavy metals in the city of Tehran.

3.3 Statistical analysis of heavy metals in PM_{10} particles of the road

As observed in Table4, the average concentration of lead, chrome, nickel, zinc and cadmium were 0.0943, 0.011, 0.0135, 0.0567 and 0.003 µg/m^3 respectively. The highest concentration average pertained to lead *viz.*0.0943 µg/m^3. Overall, it can be stated that heavy metals in the road dust have the following reducing trend: Pb> Zn> Ni > Cr > Cd. Tasdemir et al., showed that in the atmospheric weather of Turkey the metals reduce as follows (Kural et al., 2006): Ca > Fe > Mg > Cu > Zn >Pb>Mn> Cr > Ni > Co > Cd. Monir Shah and associates showed the following reducing trend for metals in the Pakistan weather (Monir Shahetal.2008):Fe>Na>Zn>K>Pb>Cr>Mn>Co>Ni>Cd.

The comparison of metals average and values declared *via* WHO and USEPA showed that, except nickel the values of metals were lesser than the standard. Averagely, the nickel level was 36 times (0.191 µg/m^3) times higher than WHO standard and 56 times higher than the USEPA standard. In the investigation of atmospheric PM_{10} in Zanjan, in a zone with a traffic load and industrial activity that the concentration of Pb, Zn, Cr and Cd was 840, 16233, 32 and 54.8 (ng/m^3) respectively (Farahmandkia et al., 2010). The highest standard deviation pertained to lead and the lowest standard deviation pertained to cadmium and the highest extension pertained to chrome. The data showed the abnormal distribution of metals in the road PM_{10} particles.

Table 4 The statistical analysis of heavy metals in PM_{10} particles in road.

	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
Pb	0.029	0.206	0.0943	0.0577	0.584	-1.069
Cr	0.006	0.026	0.0114	0.0059	1.441	81.461
Ni	0.007	0.022	0.0135	0.0056	0.272	-1.597
Zn	0.009	0.132	0.0567	0.0329	0.446	1.213
Cd	0.0004	0.005	0.0031	0.0016	-0.988	0.021

Table 5 The standards declared *via* Who and USEPA (WHO, 2000; ATSDR, 2002).

Standard (EPA) µg/m3	Standard (WHO) **µg/m3**	heavy metals
1.5	0.500	Pb
0.100	1.10	Cr
0.00024	0.00038	Ni
No data	No data	Zn
0.006	0.005	Cd

Table 6 Pearson correlation coefficients for the suspended particles in the road.

Heavy metals	Pb	Cr	Ni	Zn	Cd
Pb	1				
Cr	0.843**	1			
Ni	0.599*	0.227	1		
Zn	0.369	0.143	0.683**	1	
Cd	0.070	-0.279	0.588*	0.692**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

As shown in Table 6, in the road dust a significant positive correlation exists between lead and chrome in 1 percent level besides lead and nickel in 5 percent level. In addition, a positive correlation exists between lead and nickel and cadmium in 1 percent level and nickel and cadmium in 5 percent level. Michaela Kendall et al. showed that in the suspended particles of Turkey air a correlation exists between nickel, cadmium and chrome (Michaela et al., 2011). In the assessment of atmospheric PM_{10} in Zanjan showed that a correlation exists between lead and chrome and zinc with cadmium (Farahmandkia et al., 2010). Fig. 5 depicts the clustering analysis of road dust metals. In the clustering analysis of road dust, the metals are divided into three clusters:

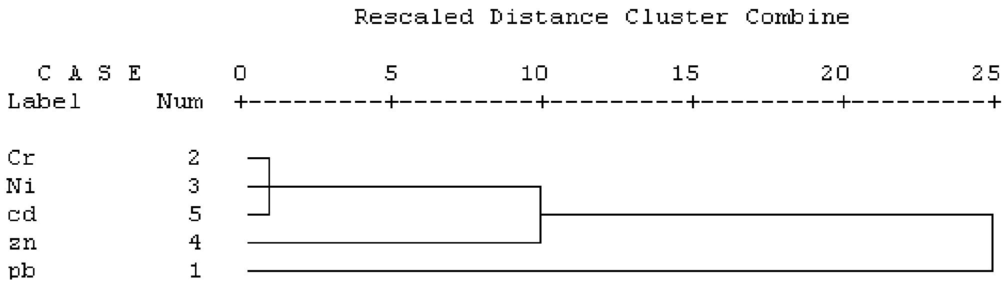

Fig. 5 Clustering analysis of road dust.

Ni et al. in clustering analysis of metals in suspended particles smaller than 100 microns in the road dusts of Xining, China obtained similar results (Ni et al., 2015).

3.4 The spatial distribution of heavy metals in road PM_{10} particles

It can be generalized from the spatial distribution map of heavy metals in the road dusts traced using Arc GIS 9.3 software that heavy metals rate is higher in the west to east route.

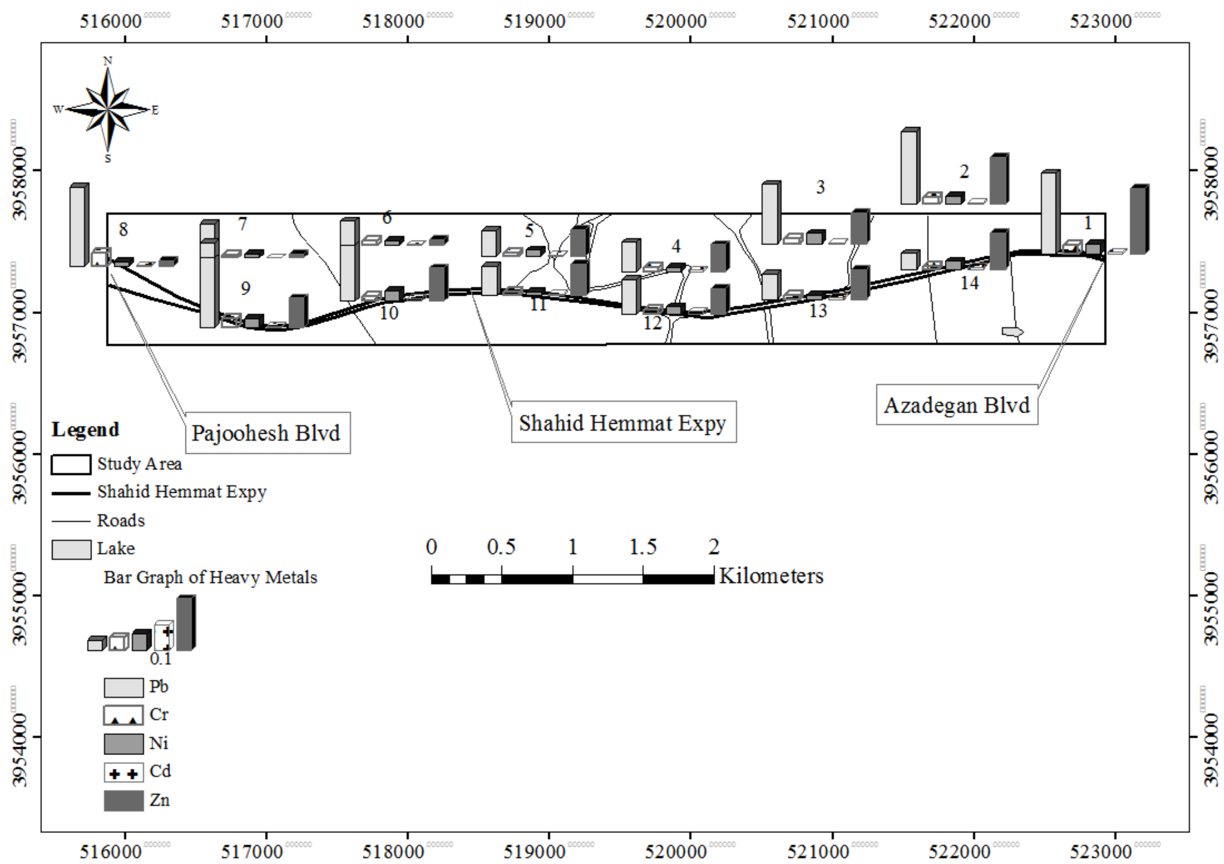

Fig. 6 The spatial distribution of heavy metals in the road PM_{10} particles of Tehran city.

3.5 Comparison of pollutants concentration in two different zones *viz.* city and road PM_{10} particles

The t-test has an application in the comparison of variables in the two society groups. As indicated in the table 7, the distribution of lead, cadmium and nickel does not have a significant difference in the city and road which shows that these metals have a common origin, whereas chrome and zinc in the city and road have a significant difference which shows that these metals in addition to traffic origin even have other varied origin.

3.6 Assessment of heavy metals health risk in the city

The heavy metals carcinogenesis and non-carcinogenesis risk was evaluated in the city dust particles. As observed in Table 8, ingestion is the main route of contact with road dust for the adults and children, followed by dermal contact, whereas the potential therapeutic risk *via* inhalation is insignificant in comparison to the other exposed routes. HI reducing trend of the case study metals was Pb>Cr>Cd>Ni>Zn for children and Pb>Cd>Cr>Ni>Zn for adults. The non-carcinogenic therapeutic danger for adults was lower than the children. Lead had the highest risk value ($0.22x10^{-3}$). HI value of case study metals was lesser than threshold level 1. Even if they are below the safe level, contact with scarce elements at high doses could cause nervous, growth and development dysfunctions. In addition, some of the heavy metals (for an example, lead has a cumulative property (Siegel, 2002). Besides, considering the frequency increase in the exposure or the consumption rate for the children, the exposure to road dust in children could show higher potential therapeutic dangers. In general, the non-carcinogenesis risk value of the entire metals was 1 (HI<1) which confirms that an anxiety in case of non-carcinogenesis effects does not exist in the urban dusts of the case study zone in Tehran.

Table 7 The comparison of pollutants concentration in two different zones *viz*. city and road.

	t-test for Equality of Means						
						95% Confidence Interval of the Difference	
	t	df	Sig	Mean Difference	Std. Error Difference	Lower	Upper
pb	-.738	19	.470	-.021001	.028455	-.080557	.038555
Cr	-2.736	19	.013	-.009043	.003306	-.015962	-.002124
Ni	-2.056	19	.054	-.005614	.002730	-.011329	.000100
Zn	-5.570	19	.000	-1.087243	.195195	-1.495790	-.678695
Cd	-1.282	19	.215	-.001129	.000881	-.002972	.000714

Among the carcinogenic metals, only cadmium, chrome and nickel were analyzed. The carcinogenesis risk levels of these two metals were higher than $<10^{-6}$exhibiting that carcinogenesis of these three metals is acceptable due to encounter with dusts of city roads in Tehran and even from the carcinogenesis risk viewpoint nil anxiety exists and besides no danger threatens the dwellers. But overall, based on the results of the published articles and the present study, the potential health risk of adults and children because of exposure to heavy metals *via* dust cannot be neglected. Even Lu et al. (2014) in the assessment of Nursing Institute of China reported similar results wherein the highest method in the exposure is ingestion of particles and even demonstrated that a danger from carcinogenesis and non-carcinogenesis risk of metals does not exist (Lu et al., 2014). Ferreira-Baptista and De Miguel (2005) and Zhang et al. (2010) also achieved similar results.

3.7 Health risk assessment of heavy metals in the road

The carcinogenesis and non-carcinogenesis risk of heavy metals was calculated in road dust particles. As depicted in Table9, ingestion is the main route of contact with the road dust for adults and children, followed by dermal contact, whereas the potential therapeutic risk danger was *via* inhalation which in comparison to the other routes in terms of exposure was almost insignificant. HI reducing trend for case study metals was as follows: Cd>Pb>Cr>Zn>Ni for the children and Pb>Cd>Cr>Ni>Zn for the adults.

The non-carcinogenic therapeutic danger for adults was lesser than children. HI level for the case study metals was lesser than threshold level 1. Overall, the non-carcinogenic risk rate for the entire metals was lesser than one (HI<1) which confirms that in the road dusts in case of non-carcinogenesis effects there is no anxiety in the case study zone of Tehran.

Among carcinogenic metals only cadmium, chrome and nickel were analyzed. The carcinogenesis risk levels for these two metals was higher than 10^{-6}exhibiting an acceptable carcinogenesis risk of these three metals because of an encounter to road dust in Tehran and even from the carcinogenesis risk viewpoint there is nil anxiety and besides no danger threatens the dwellers. But, in general, based on the results of the published articles and the present study results, the potential health danger for adults and children because of exposure to heavy metals *via* dust cannot be neglected.

Rajesh et al. showed that the non-carcinogenic suspended particles danger of Delhi is very insignificantly higher than the acceptable level and the carcinogenic risk is much higher than the acceptable level (Rajesh et al., 2012).

Table 8 Exposure dose, hazard quotient and risk for each element and exposure pathway (mg/kg.d) in city.

	Pb	Zn	Cd	Cr	Ni
RfD_{ing}	3.50×10^{-03}	0.30	0.001	0.003	0.02
RfD_{inh}	3.50×10^{-02}	0.30	0.001	0.286×10^{-4}	0.02
RfD_{dermal}	5.25×10^{-04}	0.06	0.1×10^{-4}	0.06^{-3}	0.54×10^{-2}
Sf_{inh}			6.30	42	0.84
Child					
D_{ing}	7.59×10^{-07}	7.52×10^{-07}	2.76×10^{-08}	1.34×10^{-07}	1.26×10^{-07}
D_{inh}	2.12×10^{-11}	2.1×10^{-11}	7.7×10^{-13}	3.75×10^{-12}	3.51×10^{-12}
D_{dermal}	2.12×10^{-09}	2.11×10^{-09}	7.72×10^{-11}	3.76×10^{-10}	3.52×10^{-10}
LADD			0.22×10^{-12}	0.11×10^{-11}	0.98×10^{-12}
HQ_{ing}	0.217×10^{-3}	0.251×10^{-7}	0.276×10^{-6}	0.447×10^{-6}	0.629×10^{-7}
HQ_{inh}	6.055×10^{-10}	7.006×10^{-11}	7.700×10^{-10}	1.311×10^{-7}	1.757×10^{-10}
HQ_{dermal}	4.045×10^{-6}	3.51×10^{-8}	7.717×10^{-6}	6.261×10^{-6}	6.521×10^{-8}
$HI=\Sigma HQ_i$	0.22×10^{-3}	2.54×10^{-6}	3.53×10^{-5}	5.11×10^{-5}	6.35×10^{-6}
Cancer risk			1.56×10^{-11}	5.07×10^{-10}	9.51×10^{-12}
Adult	Pb	Zn	Cd	Cr	Ni
D_{ing}	8.13×10^{-8}	8.06×10^{-8}	2.95×10^{-9}	1.44×10^{-8}	1.35×10^{-8}
D_{inh}	1.2×10^{-11}	1.19×10^{-11}	4.34×10^{-13}	2.11×10^{-12}	1.98×10^{-12}
D_{dermal}	3.24×10^{-9}	3.22×10^{-9}	1.18×10^{-10}	5.74×10^{-10}	5.38×10^{-10}
LADD			0.22×10^{-12}	0.11×10^{-11}	0.98×10^{-12}
HQ_{ing}	2.322×10^{-5}	2.69×10^{-7}	2.95×10^{-6}	4.792×10^{-6}	6.74×10^{-7}
HQ_{inh}	3.41×10^{-10}	3.95×10^{-11}	4.34×10^{-10}	7.39×10^{-8}	9.91×10^{-11}
HQ_{dermal}	6.18×10^{-6}	5.36×10^{-8}	1.18×10^{-5}	9.56×10^{-6}	9.96×10^{-8}
$HI=\Sigma HQ_i$	2.94×10^{-5}	3.22×10^{-7}	1.47×10^{-5}	1.44×10^{-5}	7.73×10^{-7}
Cancer risk			1.56×10^{-11}	5.07×10^{-10}	9.51×10^{-12}

Table 9 Exposure dose, hazard quotient and risk for each element and exposure pathway (mg/kg.d) in road.

	Pb	Zn	Cd	Cr	Ni
RfD_{ing}	3.50×10^{-03}	0.30	0.001	0.003	0.02
RfD_{inh}	3.50×10^{-02}	0.30	0.001	0.286×10^{-4}	0.02
RfD_{dermal}	5.25×10^{-04}	0.06	0.1×10^{-4}	0.06^{-3}	0.54×10^{-2}
Sf_{inh}			6.30	42	0.84
Child					
D_{ing}	9.47×10^{-04}	5.71×10^{-04}	2.54×10^{-05}	1.13×10^{-04}	1.24×10^{-04}
D_{inh}	2.65×10^{-08}	1.6×10^{-8}	7.09×10^{-10}	3.16×10^{-9}	3.47×10^{-9}
D_{dermal}	1.74×10^{-09}	1.05×10^{-09}	5.64×10^{-11}	2.11×10^{-10}	2.48×10^{-10}
LADD			1.56×10^{-13}	6.78×10^{-12}	7.99×10^{-12}
HQ_{ing}	6.202×10^{-7}	3.74×10^{-7}	2.01×10^{-8}	7.53×10^{-8}	8.87×10^{-8}
HQ_{inh}	1.733×10^{-11}	1.044×10^{-11}	5.62×10^{-13}	2.103×10^{-12}	2.48×10^{-12}
HQ_{dermal}	3.31×10^{-6}	1.74×10^{-8}	5.64×10^{-6}	3.51×10^{-6}	4.6×10^{-8}
$HI=\Sigma HQ_i$	3.93×10^{-6}	3.91×10^{-7}	5.66×10^{-6}	3.59×10^{-6}	1.35×10^{-7}
Cancer risk			9.83×10^{-13}	2.85×10^{-10}	6.71×10^{-12}
Adult	Pb	Zn	Cd	Cr	Ni
D_{ing}	6.65×10^{-8}	0.04×10^{-6}	2.16×10^{-9}	8.07×10^{-9}	$9. 5\times10^{-9}$
D_{inh}	9.77×10^{-12}	5.89×10^{-12}	3.17×10^{-13}	1.19×10^{-12}	1.4×10^{-12}
D_{dermal}	2.65×10^{-9}	1.6×10^{-9}	8.6×10^{-11}	3.22×10^{-10}	3.79×10^{-10}
LADD			1.56×10^{-13}	6.78×10^{-12}	7.99×10^{-12}
HQ_{ing}	1.9×10^{-5}	1.33×10^{-7}	2.16×10^{-6}	2.69×10^{-6}	4.75×10^{-7}
HQ_{inh}	2.79×10^{-10}	1.96×10^{-11}	3.17×10^{-10}	4.15×10^{-8}	6.99×10^{-11}
HQ_{dermal}	5.06×10^{-6}	2.66×10^{-8}	8.61×10^{-6}	5.37×10^{-6}	7.02×10^{-8}
$HI=\Sigma HQ_i$	$2. 4\times10^{-5}$	1.6×10^{-7}	1.08×10^{-5}	8.1×10^{-6}	5.46×10^{-7}
Cancer risk			9.83×10^{-13}	2.85×10^{-10}	6.71×10^{-12}

4 Conclusions

The results of the present research showed that the level of nickel in the city and the road are over the standard level and as aforesaid nickel has a traffic origin. Besides, the two metals i.e. lead and zinc has the highest concentration that with the increase of distance from the road the pollutant concentration reduces. As demonstrated by the study results of the other researchers the metals lead and zinc have traffic origin. But in this study, the metals clustering showed that zinc has a different origin wherein considering that in the case study zone the construction is carried out expansively in the city and in addition this intersection from Hemmat

Expressway is in parallel with the Tehran-Karaj Expressway whereby attaches the two provinces viz. Alborz and Tehran with one another and besides the industries are also active surrounding the Tehran-Karaj Expressway, thus it can be safely concluded that zinc could have a construction origin and or could be due to industrial activity. In road too, the level of zinc was high in the zones that surrounded the green space of the station, which could be because of the use of chemical fertilizers containing zinc to fertilize the soil and re-suspension of soil particles because of wind. In addition, the carcinogenic and non-carcinogenic risks of the metals were calculated wherein the results showed that in urban and road dusts in the case study zone an anxiety for the carcinogenic and non-carcinogenic effects does not exist. Moreover, the pollutants also followed an abnormal distribution.

The spatial distribution modeling of the heavy metals in the road dust showed that as a general rule the heavy metals rate was higher in the west to east route that could be due to the newness of this expressway and higher number of people using this expressway to enter the megacity of Tehran.

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References

ATSDR.2002. Regulations and guidelines applicable. Agencyfor Toxic Substances and Disease Registry. Retrieved from http://www.atsdr.cdc.gov/toxprofiles/tp11-c8.pdf.

EPA. 1999.Method IO-3.2. Determination of metals in ambient particulate matter using Atomic Absorption spectroscopy.In Compendium of methods for the determination of inorganic compounds in ambient air, EPA/625/R-96/010a. US-Environmental Protection Agency, Cincinnati, USA

Farahmandkia Z, Mehrasbi MR, Sekhavatjou MS. 2010. Relationship between concentrations of heavy metals in wet precipitation and atmospheric PM10 particles in Zanjan, Iran. Iranian Journal of Environmental Health Science and Engineering, 8: 49-56

Ferreira-Baptista L, DeMiguel E. 2005. Geochemistry and risk assessment of street dust in Luanda, Angola:a tropical urban environment. Atmospheric Environment, 38: 4501-4512

Gatari MJ, Boman J, Wagner A, Janhall S, Isakson J. 2006. Assessment of Inorganic Content of PM2.5 Particles Sampled in a Rural Area North East of Hanoi. Science of the Total Environment, 368: 675-685

Jandačka D, Ďurčanská D. 2014. Particulate matter assessment in the air based on the heavy metals presence. Civil and Environmental Engineering, 10: 26-39

Junhua M, Singhirunnusorn W. 2012. Distribution and health risk assessment of heavy metals in surface dusts of Maha Sarakham Municipality. Procedia - Social and Behavioral Sciences, 50: 280-293

Tasdemir Y, Kural C, Cin SS, Vardar N. 2006. Assessment of trace element concentrations and their estimated dry deposition fluxes in an urban atmosphere. Atmospheric Research, 81:17-35

Leili M, Naddafi K, Nabizadeh R,Yunesian M, Mesdaghinia A. 2008. The study of TSP and PM10 concentration and their heavy metal content in central area of Tehran, Iran. Air Quality and Atmospheric Health, 1: 159-166

Lu X, Zhang X, Chen H, LiY, Chen H. 2014.Assessment of metals pollution and health risk in dust from nursery schools in Xi'an, China. Environmental Research, 128: 27-34

Manju M, Bharat SM, UttraC, Ashu R. 2016.Seasonal Variation of Selected Metals in Particulate Matter at an Industrial City Kota, India. Aerosol and Air Quality Research, 16: 990-999

Mccullum K, Kindzierski W. 2016. Analysis of Particulate Matter Origin in Ambient Air at High Level. Project Report (2001-2016). Department of Civil and Environmental Engineering, University of Alberta, Edmonton, Alberta, Canada

Michaela K, Kayihan P, Sumru U, Seref G. 2011. Airborne particulate matter (PM2.5 and PM10)and associated metals in urban Turkey. Air Quality and Atmospheric Health, 4:235-242

Munir HS, Shaheen N. 2008. Annual and Seasonal Variations of Trace Metals in Atmospheric Suspended Particulate Matterin Islamabad, Pakistan, Water, Air and Soil Pollutant, 190:13-25

Ni Z, Lu X, Shigang C, Xue X. 2015. Multivariate statistical analysis of heavy metals in less than 100 lm particles of street dust from Xining, China. Environmental Earth Sciences, 73: 2319-2327

Pant P, Harrison RM. 2013. Estimation of the contribution of road traffic emissions to particulate matter concentrations from field measurements: A review. Atmospheric Environment, 77: 78-97

Rajesh K, Himanshu L, Arun S, Vinod KJ. 2012. Human exposure to particulate matter and their risk assessment over Delhi, India. National Academy Science Letters, 35(6): 497-504

Kumar Prajapati S, Meravi N. 2014. Heavy metal speciation of soil and Calotropis procera from thermal power plant area. Proceedings of the International Academy of Ecology and Environmental Sciences, 4(2): 68-71

Sayadi M. H, Rezaei M. R. 2014, Impact of land use on the distribution of toxic metals in surface soils in Birjand city, Iran. Proceedings of the International Academy of Ecology and Environmental Sciences, 4(1): 18-29

Sayadi, M.H., Torabi, S. 2007. Geochemistry of soil and human health: A review. Pollution Research, 28: 257-262

Shaheen N, Munir HS, Jaffar M. 2005. A study of airborne selected metals and particle size distribution in relation to climatic variables and their source identification. Water, Air, and Soil Pollution, 164: 275-294

Srinivasa RS, RajamaniNS, ReddiEUB. 2015. Assessment of Heavy Metals in Respirable Suspended Particulate Matter at Residential Colonies of Gajuwaka Industrial Hub in Visakhapatnam. International Journal of Geology Agriculture and Environmental Sciences, 3: 304-311

Su C, Zhang WJ, Jiang LQ. 2014. A review on heavy metal contamination in the soil worldwide: Situation, impact and remediation techniques. Environmental Skeptics and Critics, 3(2): 24-38

Thorpe A, Harrison RM. 2008. Sources and properties of non-exhaust particulate matter from road traffic: A review. Science of Total Environment, 400: 270-282

USEPA.1989. Risk Assessment Guidance for Superfund, Office of Solid Waste and Emergency Response vol. I: Human Health Evaluation Manual. EPA/540/1-89/002.

Vojtesek M, Mikuska P, Vecera Z. 2009. Presence, Sources and Classification of metals present in the Air (in Czech). Chemical Letters, 103: 1213-7103

Wawer M, Magiera T, Ojha G, Appel E, Kusza G, Hu S, Basavaiah N. 2015.Traffic-Related Pollutants in Roadside Soils of Different Countries in Europe and Asia. Water, Air and Soil Pollution, 226: 216-223

Weinbruch S, Ebert M. 2004. Source Apportionment of Atmospheric Aerosols Based on Electron Microscopy. Technical University of Darmstadt. India

Weiwei L,Yanxin W,Xavier Q, Xinguo Z,Andre´ SA, Angel L, Mar V.2006. Geochemical and statistical analysis of tracemetals in atmospheric particulatesin Wuhan, central China. Environmental Geology, 51:121-132

WHO. 2000. Guidelines for air quality. World HealthOrganization, Geneva, Retrieved from http://www.who.int/environmentalinformation/Air/Guidelines/aqguide7.pdf.

Yusri Y, Abbas FM. 2011. Cluster analysis of inorganic elements in particulate matter in the air environment of an equatorial urban coastal location. Chemistry and Ecology, 27: 273-286

Zheng N, Liu J, Wang Q, Liang Z. 2010. Heavy metals exposure of children from stairway and side walk dust in the smelting district, northeast of China. Atmospheric Environment, 44: 3239-3245