ARTICLE

EVALUATION OF HEAVY METALS (CHROMIUM, NICKEL AND LEAD) IN TOPSOIL OF THE RESIDENTIAL AND INDUSTRIAL AREA OF KERMANSHAH, IRAN

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ABSTRACT

Densely industrialization in metropolis vicinity and also human activities leads to rapid growth of urbanization and make great changing of ecosystem such as soil of urban area. Release of heavy metal to urban area soil has been arisen as conclusion of human activities. Soil containing Heavy metal is closely related to human health and threat the environment by accumulation in soil. In present study 75 point samples (15 composed samples) were collected. The experiments were carried out after extraction by acid digestion and by applying of ICP the heavy metals concentration including chromium (Cr), nickel (Ni) and lead (Pb) were analyzed. The result of this study revealed the average concentration of Chromium, nickel and lead in three various application were 124.04, 175.68, 632.97 mg/kg, respectively. The highest and lowest concentration of chromium were 151.58, 97.75, respectively that was observed in industrial and refrence areas, respectively. The maximum and lowest concentration of nickel were 281.88, 113.34 mg/kg, respectively in urbanization and refrence areas, and maximum and lowest concentration of lead were 796.89, 582046 mg/kg in refrence and urbanization areas, respectively. Base on obtained result in industrial and urbanization area the chromium and nickel concentration were more than in references areas and as well as the lead concentration in refrence areas was more in compared to industrial and urbanization area application. It was revealed that in industrial application the average concentration of lead was lower and in residential areas was more in respect to Canadian Council of Ministers of the Environment recommendation and as well as average concentration of chromium and nickel was higher in all of application.

KEY WORDS
Topsoil; Heavy metal; Urban Area; Urbanization

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INTRODUCTION

Soil is one the most fundamental component of the earth which also has great deal of importance in food production chain [1]. By Rapid growth of intensive urbanization, industrialization and subsequently increment of human activities has pose to considerably change in soil composition. Nowadays urbanization has become a global phenomenon and base on statistic more than half of the world population living in cities. According to prediction, urban population of the world will be rising about 68.7 percentage of the population in 2050 [2]. It is obvious that the industrialization not only increase the urban population, but also directly make the contamination. Due to increment of densely population in urban areas, in order to achieve the desired living standards, monitoring health effects and appropriate control should be considered [3]. Urban soil is an important component of urban ecosystems, which often affected by a variety of contaminants including heavy metals content which have been released from various sources to urban soil [4]. Heavy metal approximately exist in all of soils, but the urban soils characterized by higher concentration of heavy metal in compare to natural soil which is related to human activities [5]. Soil plays an important role in biochemical reactions directly and indirectly, natural cycles and consequently affected the life quality in residential areas of cities. Urban soil has more diverse properties in compared to natural and agriculture soils. In addition, urban soil often have more unusual characteristics such as poor structure, different composition, high pH, low organic matter and high pollution than in rural and agriculture soil [6]. Hence Environmental importance of HMs in the soil associated with relationship between human health and land by different ways. Since, the heavy metals in urban soils are exposed to human through inhalation, ingestion and skin contacts, and it can be accumulated in body and human's tissues. On the other hand, it can also be dangerous for human health by food through contaminated water, and soil containing heavy metals [2, 6, 7]. Growth of population and related activities, by considering the accumulation of heavy metal in surface sweeping in cities can be harmful for human health with inhalation [7]. Heavy metal (HMs) is considered often as one of the principal sources of environmental pollution which can be dangerous for human and animal health and by suspension in the air that make the reduction of air quality, affected the soil biological cycle, and because not composed by physical process, it can be accumulated in tissues. Correspond on various studies which have been carried out, heavy metal in street sweeping and topsoil can be accumulated in human body directly through breathing system and skin contact [8]. HMs affected the soil quality which makes negative impact on soil ecosystems. According to various researches in relation to contaminated soil, the accumulation of HMs in soil can reduce the activity and microbial population and as a result it leads to reduce of mineralization [7]. The HMs concentration in the air, water and soil is considered as a proper index for urban areas quality [2]. HMs accumulation in urban soils poses to reduce the biomass in soil and make the efficiency decreases in terms of agriculture and recreational soil [9]. Several extensively studies has been surveyed about the agriculture soil content heavy metal by considering the importance of food production from agricultural soils [10]. the HMs release from many sources to sweeping roadside and topsoil in cities including traffic (exhaust particles, tire particles and skids), industrial activities (industrial emissions and chimney exhaust), household emissions (fuel combustion for cooking and heating), particle

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erosion of buildings and construction and anthropogenic discharges[7, 11-14]. Li et al. (2001) have been investigated the HMs contamination of urban soils and street dusts in Hong Kong, suggested the topsoil and street dusts can be represented as proper indicators for HMs pollution [15]. Generally air and soil have mutual effect because atmosphere can release large quantity of heavy metal in to soil by sedimentation and on the other hand soil cause the increment of heavy metal in the air [16]. In addition, the soil containing HMs have been reported as an indicator of the quality of the urban environment [17]. Therefore, the presence of HMs in the soil has been considered as one of most significant health concerns, in this regard, continues assessment of these agents may have an important role in the development of strategies for health. The aim of present study was to compare assesses the concentration the heavy metals concentration of chromium, nickel and lead in topsoil with refrence soil (far away from cities) that covering the residential and industrial area of Kermanshah, Iran.

MATERIALS AND METHODS

Geographical location of study area

The study area is located in metropolis of Kermanshah the capital of Kermanshah province, the ninth most populous city in Iran, the population of this city was over 851405 people and has area of 93 389 956 km2. Kermanshah is the most important city in west of Iran [18]. The geographical location of Kermanshah in Iran is presented in [Fig. 1].

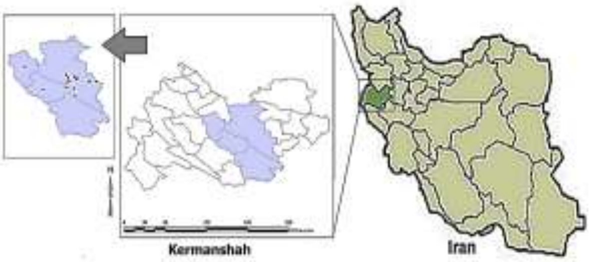

Fig.1: Graphical location of the Kermanshah in Iran map

Regions and sampling place

At first 10 regions in terms of industrial and residential applications were selected. Then 5 areas as reference area (which was not affected by any source of contamination) were determined. Each of the applications were coded that are displayed in [Table 1].

Table 1: Sampling point characteristic in the different application of study area

Sample Code	Sampling site	Longitude	latitude
A-1	Cement factory	47.286559	34.355086
A-2	Power houseplant	47.356852	34.348241
A-3	Industrial Park Road Sanandaj	47.038347	34.417458
A-4	Industrial park of Road Sanandaj	47.280359	34.345202
A-5	Petrochemical area	47.132295	34.202119
B-1	Maskan residential area	47.142689	34.377905
B-2	Zafar residential area	47.158138	34.379782
B-3	Elahieh residential area	47.071106	34.357591
B-4	Dolatabad residential area	47.046478	34.338826
B-5	Kasra residential area	47.047008	34.291477
C-1	TaqBostan Mountain Taq area	47.129015	34.400702
C-2	Kuzaran plain	46.603128	34.491739
C-3	Mahidasht plain	46.795558	34.269277
C-4	Faraman area	47.117783	34.280219
C-5	Sarab Qanbar Sarab area	47.055656	34.385941

Sampling collection method

In each application five areas were considered, and in each of determinate region, five points (area of 1 m2) were selected aim to collecting from topsoil. Topsoil in the determinate point were collected through shovel, pickaxe and sweep in depth of 0-20 cm, and after it was stored in coding polyethylene bags. Samples taken from 5 points were composed together and finally a composite sample was prepared. Generally in each application 5 samples were obtained and overall 15 composite samples (75 point samples) were collected. It should be noted that collected samples were transported to laboratory in polyethylene bags undergone standard condition [7, 8, 13, 17].

Preparation and samples extraction

At first, the samples were grinded by using of mortar and Crucible and screened through laboratory sieve (Mesh of 20), then the samples were put in in oven for 24 hours at 60 ± 5˚C [14, 19]. afterward 0.5 gr of soil sample were sited in a test tube and then 6 ml HCl (30%), 2 ml HNO_3(65%) and 3 mL of concentrated $HClO_4$ were added. Subsequently compost samples was placed in oven for 6 h at 90 ° C. after make cold the present compost samples, each samples were filtered through filter paper (Whatman 42.5mm Ashless 1442 042). The filtered solution was poured in 25 mm volumetric flask and reached to volume of 25 mm via pure distilled water (6 times distillation) [20]. Finally the present solution were injected to (ICP) Inductively Coupled Plasma (Perkin elmer 7300 DV) and heavy metal concentration of chromium, nickel and lead were analyzed. The detection limit of ICP for chromium, nickel and lead were 0.12, 0.5, 1 ppb or μg/L, respectively.

Samples analysis through inductively coupled plasma atomic emission spectroscopy
According to atomic emission spectroscopy method, plasma use as agitation source aim to quantities and qualities analysis of elements. In this method the flow of argon gas ionized by magnetic field with radio frequency of 27-40 MHz, and produced the temperature almost of 1000 kelvin. The sample via nebulizer sprayed to Argon plasma and in high temperature the sample convert to atomic particles and create emission and the emission amount was analyzed [21].

Statistical analysis

The raw data obtained from ICP base on ppm were converted to mg/kg, afterward the central tendency (mean, medium and mode) and dispersion (field changes, mean deviation, variance and standard deviation) were calculated thorough employed of Excel and SPSS software. The average concentration of each heavy metal in various applications, and also the average concentrations of heavy metals with together in a special application, compared via applied of one-way ANOVA at a significance level of (α= 0.05). In addition, the average concentration of heavy metals in each special application with concentration of heavy metals in refrence soil samples were compared as well as the standard reference by One Sample T-test at a significance level of (α=0.05). The analysis of variance was done by Tukey tests to calculate the difference between groups.

RESULTS

In five diferent industrial areas a significant difference (p-value <0.05) was showed between the average of chromium, nickel and lead concentration. So based on obtained result the maximum concentration of lead was in the cement factory and the lowest concentration relate to Faraman industrial park. It was resulted that the highest concentration of chromium was in the petrochemical and in Faraman industrial park the lowest concentration was examined. The highest concentration of nickel was 179.35 mg/kg and in range between of 174.35-179.35 in Faraman industrial park. And the lowest concentration of nickel was in the cement factory. [Table 2].

Table 2: The Chromium, nickel and lead concentration (mg/kg) in topsoil of industrial areas

Metal	Sampling	The number of repeat test	mean ± SD	P-value
Cr	Cement factory	3	88.95±2.5	<0.001
	Powerhouse	3	47.35±1	
	Industrial Park Road Sanandaj	3	67.25±2	
	Industrial Park Faraman	3	42.55±1	
	Petrochemical	3	361.80±8	
	Total	15	121.58±125.52	
Ni	Cement factory	3	99.85±2	<0.001
	Powerhouse	3	131.2±5	
	Industrial Park Road Sanandaj	3	145.05±4	
	Industrial Park Faraman	3	176.85±2.5	
	Petrochemical	3	106.15±3.5	

	Total	15	131.82±29.05	
Pb	Cement factory	3	614.5±15	<0.001
	Powerhouse	3	515±15	
	Industrial Park Road Sanandaj	3	563±10	
	Industrial Park Faraman	3	501.25±7.5	
	Petrochemical	3	539±18.5	
	Total	15	546.55±42.99	

It was concluded that the average concentration of chromium, nickel and lead, in five different residential areas, had a significant difference (p-value <0.05), as can be observed, the maximum concentration of chromium and lead were in residential areas of Zafar and the lowest concentration of chromium and lead were in residential areas of Kasra. It was also found that Nickel in the residential areas of Elahieh was the highest concentration but and in the residential areas of Maskan the Nickel was at lowest concentration [Table 3].

Table 3: The Chromium, nickel and lead concentration (mg/kg) in topsoil of residential areas

Heavy Metal	Sampling point	Regional Municipality	The number of repeat test	Mean ± SD	P-value
Cr	Maskan	5	3	112.9±3.5	<0.001
	Zafar	5	3	165.85±7	
	Elahieh	6	3	137.85±5.5	
	Dolatabad	2	3	112.9±4	
	Kasra	4	3	84.4±1.5	
	Total	-	15	122.78±28.62	
Ni	Maskan	5	3	164.6±1.5	<0.001
	Zafar	5	3	349.8±2.5	
	Elahieh	6	3	364.45±3.5	
	Dolatabad	2	3	293.4±3.5	
	Kasra	4	3	237.15±2.5	
	Total	-	15	281.18±76.55	
Pb	Maskan	5	3	401.1±4.5	<0.001
	Zafar	5	3	1034.5±12	
	Elahieh	6	3	575.5±6.5	
	Dolatabad	2	3	521±5.5	
	Kasra	4	3	380.2±4	
	Total	-	15	582.46±245.9	

Table 4: The Chromium, nickel and lead concentration (mg/kg) in soil profile reference

Metal	Sampling	The number of repeat test	mean ± SD	P-value
Cr	Mountain Taq	3	148.75±3.5	<0.001
	Plain Kuzaran	3	102.7±3	
	Plain Mahidasht	3	110.2±2.5	
	Faraman area	3	53.4±2.5	
	Qanbar Sarab area	3	74.2±3	
	Total	15	97.85±33.7	
Ni	Mountain Taq	3	137.85±1.5	<0.001
	Plain Kuzaran	3	127.45±2	
	Plain Mahidasht	3	139.95±1.5	
	Faraman area	3	68.75±1	
	Qanbar Sarab area	3	92.7±2	
	Total	15	113.34±29.02	
Pb	Mountain Taq	3	914±8	<0.001
	Plain Kuzaran	3	934±12.5	
	Plain Mahidasht	3	1101±17	
	Faraman area	3	341.95±3.5	
	Qanbar Sarab area	3	558.5±5.5	
	Total	15	769.89±287.42	

It was also revealed in the refrence soil areas a significant differences between 5 diferent of chromium, nickel and lead concentration was reveled (p-value <0.05). As shown in [Table 4], the maximum concentration of nickel and lead relates to Mahidasht plain and also the highest concentration of chromium was in Taq Boston Mountain and the lowest concentration of chromium, nickel and lead were detected in Faraman area. In reference application and far away area from contaminated source, the natural sources such as precipitation, wind erosion and natural rock erosion may be attributed to cause of releasing of heavy metal to soil. On the other hand, sedimentation of particles that heavy metal containing can be released of heavy metal to topsoil of faraway areas.

The Chromium, nickel and lead concentration (mg/kg) in different applications are presented in [Table 5]. Corresponding to Kelly and his colleagues study in Great Britain in 1996, the topsoil of industrial zones in compared to topsoil of non-industrial areas had highest concentration of heavy metals [22].

Table 5: The Chromium, nickel and lead concentration (mg/kg) in different applications

Metal	Application	The number of repeat test	Median	Mean ± SD	P-value
Cr	industrial areas	15	67.25	121.58±125.52	
	residential areas	15	116.4	122.78±28.62	
	soil profile reference	15	102.7	97.85±33.7	
	Total	45	89	106.98±65.47	
Ni	industrial areas	15	131.2	131.82±29.05	
	residential areas	15	293.4	281.18±76.55	
	soil profile reference	15	127.45	113.34±29.02	
	Total	45	194.45	253.37±376.89	
Pb	industrial areas	15	539	546.55±42.99	
	residential areas	15	521	582.46±245.9	
	soil profile reference	15	914	769.89±287.42	
	Total	45	539	626.06±417.16	

Table 6: Comparison of metal concentration in different applications couple

Metals	Comparison couple	industrial areas		residential areas		soil profile reference	
		residential areas	soil profile reference	industrial areas	soil profile reference	industrial areas	residential areas
Cr	P-value	1	0.991	1	0.987	0.991	0.987
Ni		0.980	1	0.980	0.954	1	0.954
Pb		1	0.866	1	0.954	0.866	0.954

As shown in [Table 6] the Comparison of metals concentration in different applications couple are presented. Despite intensive industries such as chinaware production, production of automobile spare parts, lock and ignition switch, printing and packaging, printing, coating and packaging, production of citric acid and raw materials of food, polyethylene pipes double production, casting, rolling and effluent containing metal which discharge into the environment has pose to increasing the concentration of metals in the topsoil. The deposition of dust from mining and industry can be increased the concentration of heavy metals in soil. Due to the high traffic of vehicles in industrial areas to transport goods and fuel consumption by various devices in these areas, the concentration of heavy metals has been increased. According to the results of the present study it was assigned to largest concentrations of heavy metals was detected in industrial areas.

Based on obtained result by Marjorie and Hurley at the University of South Carolina in 2006 which has been detected, the highest concentration of heavy metals was arsenic, and in residential areas, the concentration of arsenic, chromium and lead were 0.39, 210 and 400 mg/kg, respectively [23].

Erosion in residential building, construction, painting of building, pesticides usage and cleaners can be the possibility of releasing of heavy metals to topsoil. Historical , texture, density, distance from the park center, type of fuel ,heating appliances in homes, home workshop and setting up some applications, such as doors and windows, repair of household appliances and etc. have a significant role in respect to increase the of heavy metals concentration in residential areas topsoil. In comparison point of view, the average concentration of metals in residential area of Kermanshah in terms of subjected to CCME recommendation, chromium, nickel and lead concentration were higher than the concentration which has been recommended by CCME, and As well as compare to monitoring and control standards of Taiwan, chromium and lead were lower than standard and nickel concentration were higher than standard which has been determined [24].

Base on the Alloway result about chromium concentration in earth crust was 100 mg/kg and according to Kabata et al. result the chromium concentration in topsoil and natural soil were 122 mg/kg [25, 26]. In comparison point of view, the chromium concentration was lower to mentioned studies and monitoring and control standards in Taiwan and was higher than CCME recomandation. Shacklette in 1984 was reported the soil nickel concentration in the world was varying range between 0.2-450 mg/kg [27]. And also base on Adriano study in 2001 the nickel concentration was approximately 80 mg/kg [28]. The nickel concentration in topsoil of Kermanshah was 113.34 mg/kg that had the limitation of Shacklette report but it was also reveled higher concentration than earth crust. the nickel concentration was higher In compare

to mention study and acording to CCME recomndation and was lower based on Monitoring and control standards in Taiwan [24].
The lead concentration in topsoil of Kermanshah city was 769.89 mg/kg and was significantly higher in compared to 14.8 mg/kg in earth crust [29].

The mean lead concentration in non-contaminated in throughout the world has been surveyed and it was 17 mg/kg [30]. This lead concentration in topsoil has been confirmed by various research [27, 31-32]. In other soil study in large scale the lead concentration was higher [33, 34].
But on respect to the some document the lead concentration which was measured in many areas has been originated from human activities [35-37].

Base on result the lead concentration was higher in compare to declared study and CCME recommendation and was lower in respect to Monitoring and control standards in Taiwan [24].

CONCLUSION

In present study, assessment of chromium, Nickel and lead concentration in study area of Kermanshah ,Iran that covering industrial, residential and reference area in topsoil were taken place. The result of this study showed the chromium and nickel concentration in topsoil of industrial and residential were higher than reference soil and the lead concentration in reference soil was more in compared to industrial and residential topsoil. It was concluded the average concentration of chromium, Nickel and lead in three covering application were 124.04, 175.68, 632.97 mg/kg, respectively. In comparison point of view, the chromium concentration was lower in respect to Monitoring and control standards in Taiwan and was higher than CCME recommendation. the nickel concentration was higher In compare to to CCME recommendation and was lower based on Monitoring and control standards in Taiwan. Lead concentration was higher in terms of CCME recommendation and was lower in respect to Monitoring and control standards in Taiwan.

CONFLICT OF INTEREST
There is no conflict of interest.

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FINANCIAL DISCLOSURE
None

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