Article

Impact of land use on the distribution of toxic metals in surface soils in Birjand city, Iran

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Abstract
Accumulation of toxic metals in the soil is one of the most important issues and treats plants, animals and humans. The aim of this study was to investigate the impact of land use on the distribution of Pb, Cu, Ni, Cr, Zn and Cd in the surface soils of Birjand city (Amir Abad Area). Dairy farm, agriculture, roads, residential-road, residential-agriculture and educational centre land use were studied. The samples were taken from depth of 0-20 cm at 16 stations, as regular grid soil sampling. After digestion with perchloric acid and nitric acid, the concentration of toxic elements was measured using atomic absorption. The results show the highest concentration of Pb (166.64 mg/kg) is found in the station number 10 in residential–road land use. The highest zinc concentration (346.50mg/kg) is shown at the station number 1 in dairy farm land use. The maximum concentration of cadmium (8.57 mg/kg) was at station number 10 with residential–road land use. The mean concentration of cadmium element is greater than the threshold values. While mean concentrations of other elements when compared to other researches shows high values, indicating that the soil is contaminating and in the near future the concentration of toxic metal will be beyond the threshold values. So entry of toxic elements into the human food chain greatly increases. It can suggest, in order to cleanup and reduce the rate of increases toxic elements in the soil and special management and considerations may apply.

Keywords soil contamination; heavy metals; land use; public health.

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1 Introduction

Urban soils were contaminated by different pollutants including heavy elements which are accumulated in long term. Studies on soil contamination began in earnest from 1960 and in 1966, contamination of heavy metals into the soil introduced (Purves, 1966). Contamination of soils with heavy metals is expanding and become a major issue and unavoidably (Meravi and Prajapati, 2013). Many human activities cause the entry of toxic elements in soils, so that the pollution intensity is higher than natural soils and soon will be out of standard range and serious threats to human health (WHO, 2003; Wilson and Temple 2001). Urban activities in different ways release the heavy metals in urban soils. For example, the transport of passengers and goods (Tirusha Thambiran and Roseanne, 2011), industries, factories and mining (Sayadi et al, 2009), agriculture (Wong et al., 2002; Mico et al., 2006), dairy farms (Nicholson et al, 2003), dust (Lin et al., 2005), municipal waste (Sayadi and Sayyed, 2010), and municipal and industrial wastewater (Mapanda et al., 2005) could be noted. Among the human activities, vehicles (such as brake and exhaust) and various agricultural activities and workshops are responsible for most of the contamination of soils (Zehetner et al., 2009). Given the importance of soil pollution and its negative impact on public health and the environment, many studies have been conducted in various cities around the world, Like Hong Kong (Li and Liu, 2001), Syria (Moller et al., 2005), Ireland (Dao et al., 2013) Italy (Manta et al., 2002) Spain (Jose´ Antonio Rodrı´guez et al., 2008) Zimbabwe (Mapanda et al., 2005) Australia (Tiller, 1992) China (Wu et al., 2011) and also some cities in Iran such as Tehran (Sayyed and Sayadi, 2011), Isfehan (Amini et al., 2007), Kerman (Noori et al., 2009), Hamadan (Karami et al., 2011).

Heavy metal contamination of soils in urban researchers has studied a variety of toxic elements. Choose the heavy elements is based on previous studies of similar areas. Urban soils is strongly influenced by human activities, especially in parks, roads and surrounding building which soils prepare from other areas. So the soil geochemical studies makes difficult. The main objective of this study was to assess the toxic elements and identifying pollution sources of heavy metals in surface soils with different land use.

2 Materials and Methods

2.1 Study area

Amir-Abad city at vicinity of Birjand city is a relatively small city with a population of 1,000 and located on the west side of Birjand city which is from south Khorasan province. Existence of faculty of agriculture along with numerous Livestock farming and agricultural activities is given special status to this area. Urban activities, different workshops and small settlements, and also one of the main highways in the region of south Khorasan province are potential sources of heavy metals pollutants that threaten the environment. Dairy farm, agriculture, roads, residential- road, residential-agriculture and the educational centre land use are studied. Table 1 shows the land use along with geographical coordinates of the stations under study.

It should be noted that the stations number 2, 3, 4 and 5 are without a certain user and contains only low-traffic roads.

Table 1 Geographic coordinates and land use of the sampling stations.

Stations No:	Land use	Geographical coordinates		Stations No:	Land use	Geographical coordinates	
		N	**E**			**N**	**E**
1	Dairy farm	32.860	59.141	9	Residential-Road	32.869	59.145
2	-	32.861	59.143	10	Residential-Road	32.865	59.143
3	-	32.859	59.153	11	Residential-Agriculture	32.865	59.151
4	-	32.855	59.158	12	Agriculture	3.868	59.158
5	-	32.865	59.142	13	Residential-Agriculture	32.878	59.138
6	Educational centre	32.866	59.143	14	Residential-Agriculture	32.879	59.142
7	Road	32.867	59.143	15	Agriculture	32.880	59.152
8	Road	32.862	59.158	16	Agriculture	32.881	59.155

2.2 Sampling and analysis of soil samples

Soil sampling were taken from depth of 0-20 cm in a regular network in 16 stations, each stations were sampled with 5 sub samples in three replicates. Geographical locations of the sampling stations were determined using a global positioning system tool. After mixing the 5subsamples for each station, 1.5 kg soil sample is taken (Sayadi and Sayyed, 2011). The soil samples were air-dried and then passed through 2 mm sieve. After digestion with perchloric acid and nitric acid, the concentration of toxic elements was measured using atomic absorption (Page et al., 1982; Burt, 2004).

3 Results

Table 2 shows the mean concentrations of toxic elements in surface soils of Amir-Abad city. As Table 2 shown the mean concentrations of toxic elements at the stations are not equal and significantly different (Pvalue <0.001). As Table 2 shows that the highest concentration of Pb (166.64 mg/kg) relevant to station No. 10 with residential–road land use and the lowest concentration of lead (12.2 mg/kg) relevant to Station No. 3 without any special land use. The highest copper concentration (226.7 mg/kg) was detected at station No. 9 with residential-road land use and the lowest value (11.4 mg/kg) found at station No. 3 without any special land use. The highest zinc concentration (346.50 mg/kg) is obtained at station no.1 with dairy farm land use and The lowest value (18.23 mg/kg) were observed at station no. 5 without any special land use. The highest concentration of nickel (99.48 mg/kg) was found at the station number 9 with residential–road land use and the lowest value (10.07 mg/kg) is shown at station number 12 in the agriculture area. Station No. 10 in residential-road area has shown the maximum amount of Cr (192.03 mg/kg) and the lowest value (15.42 mg/kg) found at station no. 2 without any special land use. The highest concentration of cadmium (8.57 mg/kg) observed at station no. 10 with Residential-Road land use and The lowest value (0.05 mg/kg) observed at station no. 2 without any special land use.

Table 2 Average concentrations of heavy metals in the soils from different stations (mg/kg).

Station No:	Land Use	Pb	Cu	Zn	Ni	Cr	Cd
1	Dairy farm	19.4	165.11	346.50	89.9	81.7	1.3
2	-	13.9	17.1	33	26.31	15.42	0.05
3	-	12.2	11.4	24.79	19.02	20.11	0.6
4	-	15.4	11.7	21.2	20.74	22.63	0.82
5	-	17.33	20.6	18.23	16.66	34.25	0.36
6	Educational Centre	28.17	19.3	56.66	33.85	59.7	1.7
7	Road	62.82	41.58	125.2	41	23.14	0.69
8	Road	65.14	37.5	93.04	37.5	67.45	0.44
9	Residential- Road	109.90	226.7	118.04	99.48	186.34	2.92
10	Residential- Road	166.64	202.61	122.58	72.13	192.03	8.57
11	Residential-Agriculture	45.37	48.03	112.98	32.11	64.67	1.59
12	Agriculture	58.24	30.29	80.10	10.07	56.8	0.46
13	Residential-Agriculture	49.75	36.27	105.39	22.04	36.60	1.01
14	Residential-Agriculture	33.44	42.53	127	35.51	36.92	0.93
15	Agriculture	22.20	24.45	68.55	17.84	88.73	1.46
16	Agriculture	25.57	27.22	52.17	26.27	34.40	1.51
Minimum		12.20	11.40	18.23	10.07	15.42	0.05
Maximum		166.64	226.70	346.50	99.48	192.03	8.57
Mode		30.81	33.28	86.57	29.21	46.86	0.97
Mean		46.59	60.15	94.09	37.53	63.79	1.53
Standard deviation		41.27	70.24	77.99	26.50	53.71	2
PValue		0.000	0.000	0.000	0.000	0.000	0.000

Table 2 summarizes the overall statistics of the measured parameters in surface soils of the study area. Table 2 shows that the concentrations of toxic elements in the study area were listed as Zn> Cr> Cu> Pb> Ni> Cd. Although the maximum concentrations of trace elements like zinc have a significant impact on the mean concentration.

4 Discussion

Modernization and urbanization phenomenon has become a critical problem for soil pollution. Therefore from different ways enter to the food chain and can cause serious and sometimes fatal diseases such as cancer. Table 3 shows that comparison between the mean concentrations of heavy metals in the study area with natural concentrations of these elements in Tehran and China and also the threshold limits of these elements in the soil.

Table 3 Concentrations of heavy metals in the study area and the concentration of these elements (mg\kg).

	Pb	Cu	Zn	Ni	Cr	Cd
Study Area	46.59	60.15	94.90	37.53	63.79	1.53
Tehran [1]	5.12	9.62	11.26	11.56	10.36	0.34
China [2]	26	22.6	74.2	26.9	61	0.097
Threshold Limit [3]	100	75	200	40	75	1

[1]Sayadi and Sayyed 2011; [2]CEPA, 1990; [3]HGR 2000.

Table 3 shows the average concentration of Cd element is greater than the threshold limit and natural concentration in Tehran and China. The mean values concentrations of all elements is higher than natural concentrations of these elements in Tehran and China indicating soil contamination in the study area maybe beyond the threshold limit in the near future.

Tables 2 and 3 show that the concentrations of Pb, Cu, Ni, Cr, and Cd are higher than the threshold limit at the stations number 9 and 10 with residential- road land use. The concentration of Cu, Zn, Ni, Cr, and Cd is higher than the threshold limit at station No. 1 with dairy farm land use. The concentration of Cr and Cd is higher than the threshold limit at station no. 15 with Agriculture land use. The concentration of Cd is also higher than the threshold limit at station numbers 6, 13,11and 16.

4.1 Impact of land uses on the concentration of toxic elements

Pb

Fig. 1 shows the mean concentration of Pb in the different land uses. As shown in Fig. 1, the highest concentration of Pb observed in residential-roads and then road land use, as residential-roads land use is higher than the threshold limit, the lowest concentration of Pb was found in the stations without any special land use.

Pb is usually added to the environment from activities of mining, metallurgical, sewage systems, and smoke from burning gasoline vehicles. Use of fertilizers and pesticides for agricultural purpose are releasing Pb to the soils. Battery industry, munitions, soldering, alloys, pigments are also other sources of Pb in the environment (Patel et al., 2006).

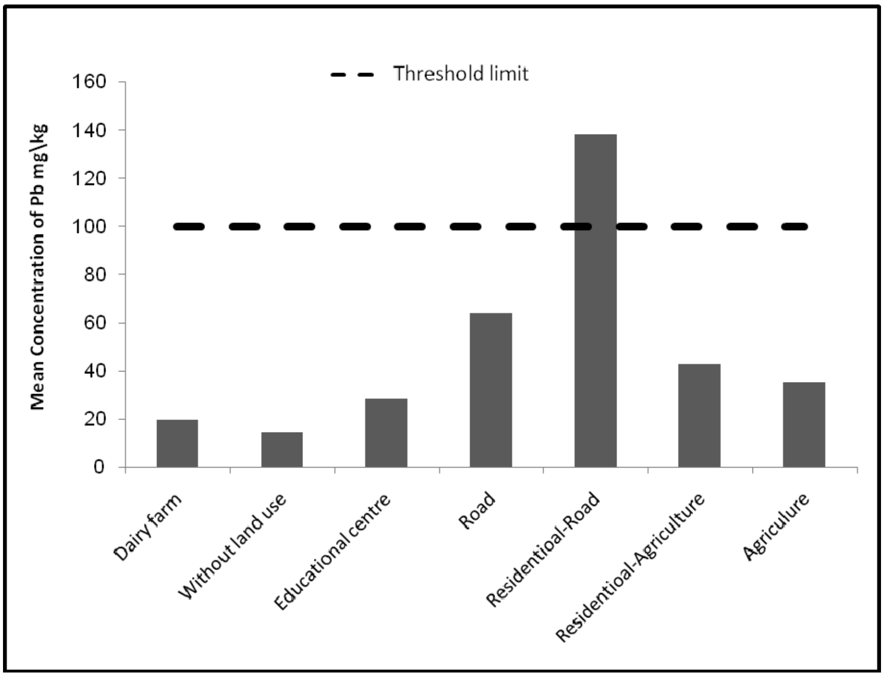

Fig. 1 Pb concentrations in various land uses.

Chronic Pb poisoning often occurs and growing children, pregnant women and the elderly are most at risk for Pb poisoning. The affect of Pb and bone and bone marrow cause anemia. Other symptoms of poisoning are neurological disorders that often lead to paralysis. Accumulation of Pb in the liver and kidneys are impaired in their work as well as high levels of Pb concentration in children causes' acute Pb encephalitis (Homdy et al., 2002).

Table 2 shows that the stations 7, 8, 9, 10 have the higher Pb concentrations. Thus it can be concluded that the main sources of Pb pollution in the region is transportation system. Similar results have been obtained in different parts of the world (Zehetner et al., 2009; Wu et al., 2011; Guney et al., 2010).

Cu

Fig. 2 shows the mean concentration of Cu in the different land uses. As shown in Fig. 2, the highest concentration of Cu found in residential-roads and then dairy farm land uses which are also higher than the threshold and the lowest concentration of Cu was found in the area without any special land use.

Cu extensively used in electrical cables, various alloys, pigments, cooking equipment, pipelines, chemical plants, fertilizer, pesticide and melting furnace, that could be environmental pollution sources (Gowd and Govil, 2008). Although, Cu is an essential element for human health but in higher concentration cause neurological effects, liver and kidney dysfunction, anemia, intestinal distress, coma and even death (Siegel, 2007). Table 2 shows the stations 1,9,10 have higher copper concentration. So we can conclude that dairy farm and residential activities along with transportation system are the main sources of Cu pollution in the region. Similar results have been obtained in different parts of the world (Nicholson et al., 2003).

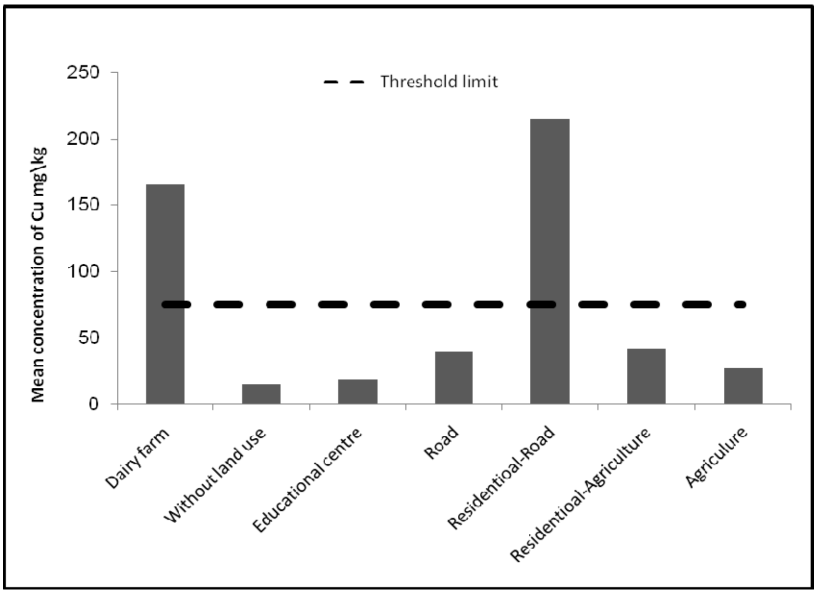

Fig. 2 Cu concentrations in various land uses.

Zn

Fig. 3 shows the mean concentration of Zn in the different land uses. As shown in Fig. 3, the higher concentration of Zn found in dairy farm land use and then residential-roads, roads and residential–agricultural land uses. The mean concentration of Zn in dairy farm land use is more than threshold values and the lowest concentration of Zn was found in the area without any special land use.

Zinc is necessary element for humans, animals and plants and often be found in the limestone soils. Chemical fertilizers and pesticides and pigments are added Zn to the environment and Zn is also used in a variety of alloys such as bronze and brass (Romic and Romic, 2003). Anemia, muscle pain, stroke, blood diseases and even death are from complications of zinc excess (Roa et al., 2001; Pais and Benton, 1997).

Fig. 3 shows that the soil around dairy farm contains considerable amounts of zinc, which is even higher than the threshold limit. In a study conducted in agricultural soils in England and Wales showed 37-40% of Zn concentration on agricultural soils is due to animal manure (Nicholson et al., 2003).

Ni

Fig. 4 shows the mean concentration of Ni in the different land uses. As shown in Fig. 4, the highest concentration of Ni found in dairy farm and then residential-roads land uses which are beyond the threshold limit. While the lowest concentration of Ni found in the area without any special land use.

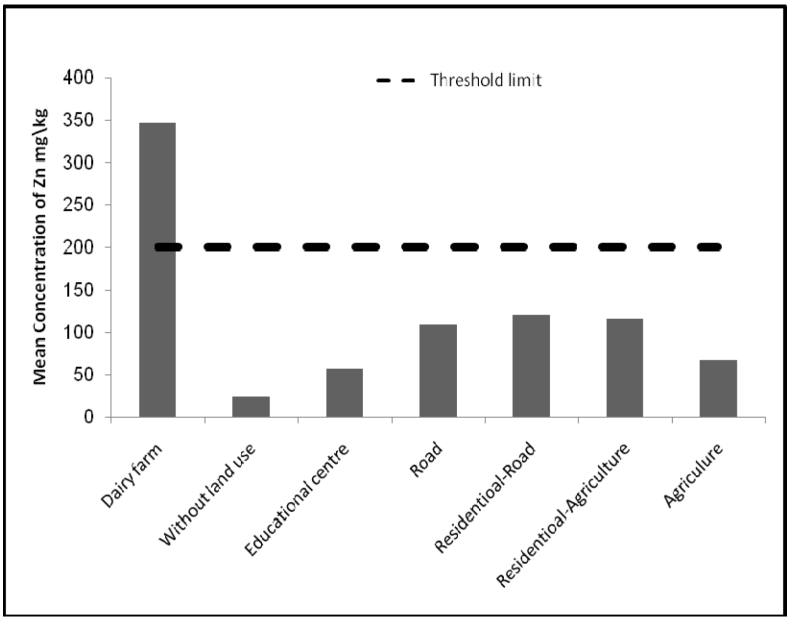

Fig. 3 Zn concentrations in various land uses.

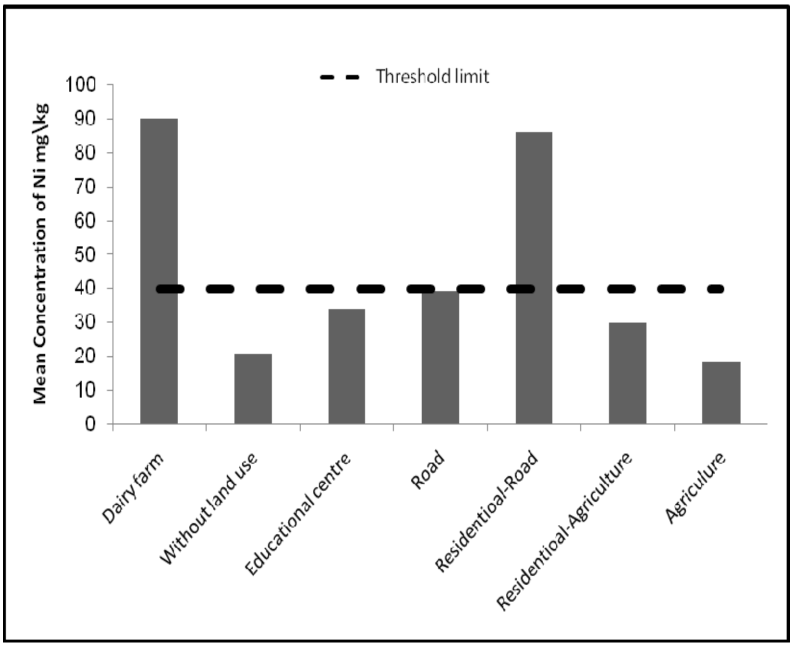

Fig. 4 Ni concentrations in various land uses.

Nickel metal used by humans, mainly in batteries and storage tanks of petroleum products and natural weathering of rocks, especially basalt stones releasing Ni into the environment (Demirel, 2006; Sayadi and Torabi, 2009). Nickel can replace the essential element in the structure of enzymes and breaks down the metabolism pathway (Vincoli, 2003). It is carcinogenic in high concentrations, increasing the threat of heart and liver, as well as weight-reducers (Homady et al., 2002). Table 2 and Fig. 5 show that the soils surrounding residential-road and dairy farm areas containing considerable amounts of nickel element which is accumulate in the soils by different ways. Other studies have reached similar results (Mapanda et al., 2005; Sayadi et al., 2010).

Cr

Fig. 5 shows the mean concentration of Cr in the different land uses. As shown in Fig. 5, the higher concentration of Cr found in residential-roads and then dairy farm land use in the study area and beyond the threshold limit. While the lowest concentration of Cr found in the area without any special land use.

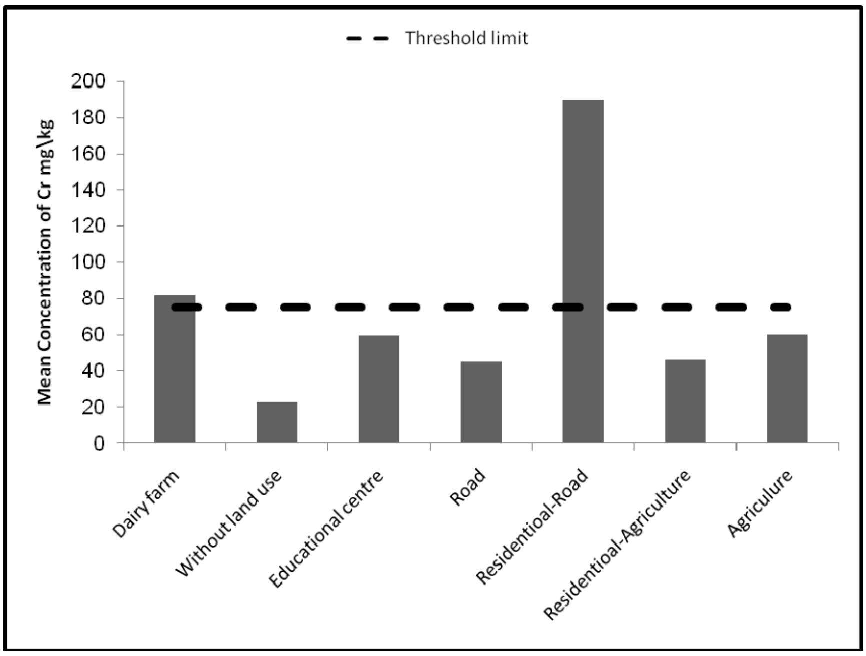

Fig. 5 Cr concentrations in various land uses.

The possible sources of Cr are textile, leather, pharmaceuticals and metals activities. Pigments containing chromium, oil and grease compounds also contain some Cr (Kumar et al., 2008). Cr is an essential component for the metabolism of fats and protein but high concentrations of Cr (VI) may damage the liver and kidneys and can cause cancer (Krishna and Govil, 2004).

Table 2 and Figure 5 show that the soil surrounding residential-roads and dairy farm areas contain high amounts of Cr that these results are obtained by other researcher. (Moller et al., 2005; Sayadi et al., 2009).

Cd

Fig. 6 shows the mean concentration of Cd in the different land uses. As shown in Fig. 6, the higher concentration of Cd found in residential-roads and then educational centre land uses in the study area while the lowest concentration of Cr found in the area without any special land use. It is interesting to note that, the concentration of Cd in soils under studied are exceeded the thresholds limit in various land use with the exception of road land use and the area without any special land use.

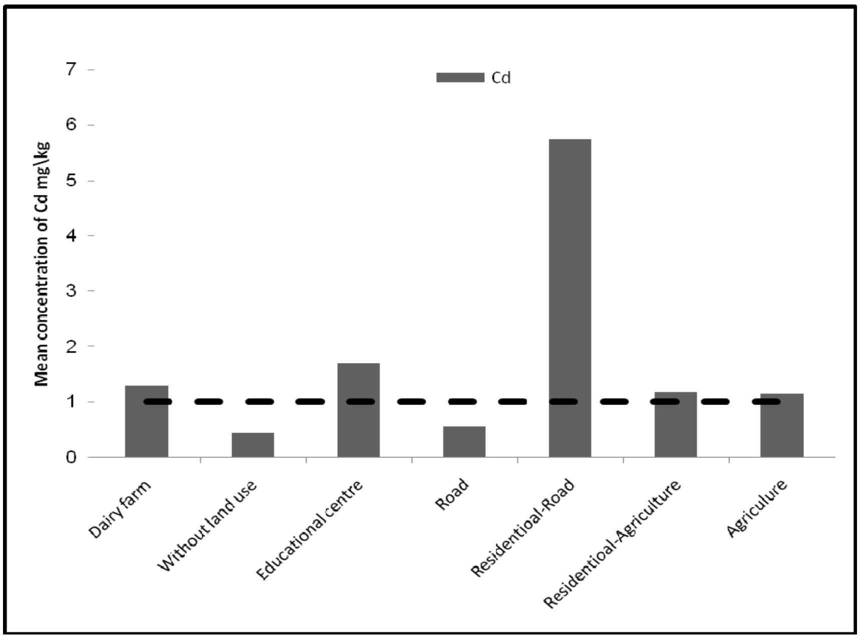

Fig. 6 Cd concentrations in various land uses.

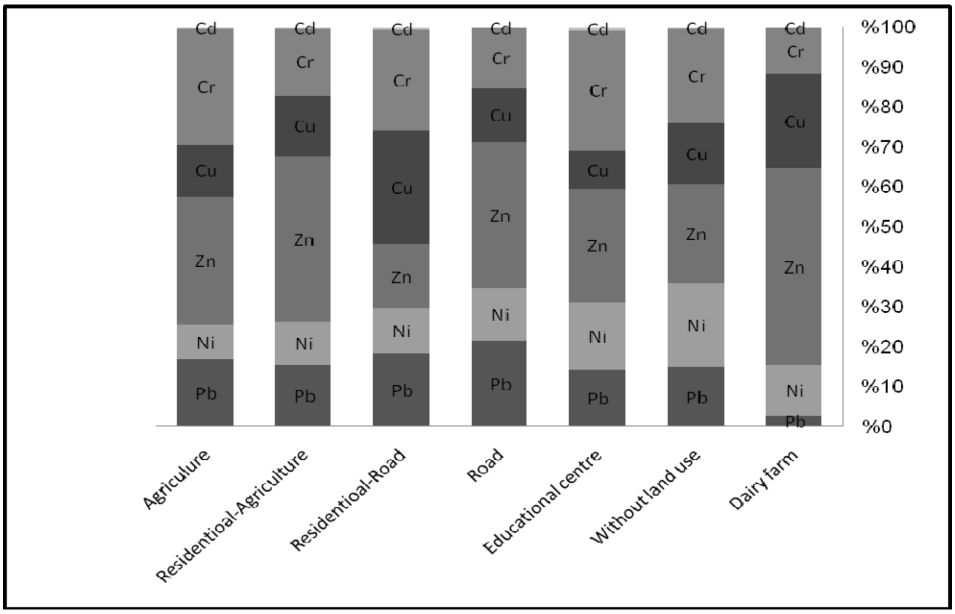

Fig. 7 percentage distributions of heavy metals concentrations in various land uses.

Batteries factories, pigments, plastics, ceramics, glass and plating jewelry materials will enter cadmium into the soil and are sources of cadmium pollution in the environment (Gowd and Govil, 2008).

Chronic kidney disease; cardiovascular disease; anemia; respiratory system; cancer of the prostate, lung and skin; rickets and dental caries cadmium pollution are some of the Cd complications (Siegel, 2007). Cadmium threshold limit is 1 mg/kg (Table 3). Table 2 and Figure 6 show that Cd concentration of the most of the surface soil is exceeded threshold limit and seriously threatens its residents' health. Suggesting further studies carry out on human disease with its relationship to the distribution of Cd concentration in soil in the study area.

4.2 Percentage distribution of toxic elements in different land uses

Fig. 7 shows the mean concentration of the toxic metals in the different land uses. As shown in Fig. 7, Residential-road land use has the highest percentage distribution of toxic metals, chromium, cadmium and dairy farm lands has the highest percentage of zinc and nickel.

5 Conclusion

The main sources of entry of heavy metals in the soil of by human activities arise by the modernization and urbanization phenomenon. According the obtained results it can be concluded that among different land use, the soils in the Residential-Road land use accumulate higher rate of Pb, Cd, Cr and Cu concentrations. Ni and Zn is more accumulated in dairy farm land use, however residential-road land use is also having a significant amount of these elements.

Considering that the mean Cd concentration and Cd concentrations in most of the stations is greater than the threshold value, so can easily enter the human food chain. More specifically, the study area is agriculture and Dairy farm area and their production of this area transport even to other city, so can cause a variety of illnesses and diseases. With a few exceptions the average concentration of toxic elements (except Cd) is a lower threshold limit but in comparison with other urban areas is high, indicating the toxic elements are increasing into the soil and with the gradual increase of toxic elements in the soil and enter to the food chain of human beings and expected to exceed from the threshold limit in near future. Suggesting to reduce the increasing rate of these elements into soils and the reduction of toxic elements in the soil must be special management and largely considerations be provided to community health and the relationship between the concentration of toxic metals (particular Cd) in surface soils and chronic disease in the study area is assessed.

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