Distribution characteristic and assessment of soil heavy metals in Ulaanbaatar, Mongolia

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Abstract

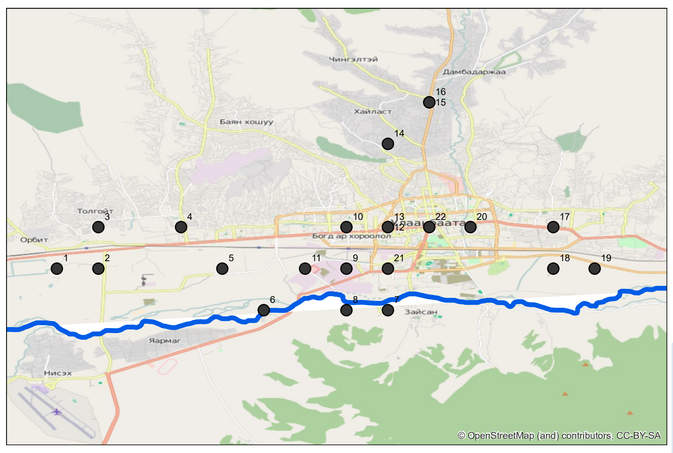
The main purpose of this study was to investigate the current status of heavy metal pollution of the soil in Ulaanbaatar, the capital city of Mongolia. The pollutions of heavy metals in urban soils are affected by multiple factors including land uses, air pollution, household solid wastes, and automobiles. Total twenty-two soil samples were collected in a depth of 0-5 cm of soil surface from different parts of the city and analyzed for their As, Cr, Pb, Zn, Ni, Cu, Co, V, Ca, Mn, Fe, and Al. The concentrations of these metals were in the range of 5.0–45.0 mg/kg for As, 110.0 –757.0 mg/kg for Cu, 4.0–72.0 mg/kg for Pb, 47.0–82.0 mg/kg for V, 5.0–7.50 mg/kg for Co 9.0–21.0 mg/kg for Cr, and 66.0–260.0 mg/kg for Zn, respectively. The concentrations of Cu and As at all the sampling sites were exceeded the permissible level (100 mg/kg for Cu, 6 mg/kg for As). Concentrations of Pb, V, Co, Cr, and Zn at several sites exceeded the permissible level (Mongolian soil standard (MNS5850:2008)). The extent of soil metal contamination was assessed using the crustal enrichment factor (EFc). The EFc values for Cu were significantly high (e.g., 11.67–55.24) at studied sites, indicates that high degree of Cu contamination from anthropogenic sources. The main sources of Cu in urban can be tire abrasion, the corrosion of metallic parts of cars, lubricants and industrial and incinerator emissions. Arsenic (As) had the second highest EF values among metals studied (2.52–23.5). The source of As pollution in soil appears to be the coal combustion in power plants and stoves in Ger district. Lead (Pb), Zn, and Ni exhibited moderate enrichment (average EF values were between 3.01-4.75). This enrichment may be related to the remarkable increase in the number of used vehicles and the increase in the use of leaded fuel in recent years. The other elements (Co, Cr, Mn, Fe Ca. Ni and V) displayed relatively lower EF values (EF<1 or close to 1) indicating that these metals in soil are originated from natural sources dominantly.

Introduction

- Ulaanbaatar, a capital city of Mongolia, a home of almost 1.4 million people. Past several decades the mobility to city from rural areas increased drastically resulting in high demand for consumption and production of waste and other unwanted products which stresses the environment.
- The soil erosion and contamination spread all over Ulaanbaatar due to expanding ger district, illegal land applications.
- There are almost no soil-reclamation activities, such as covering soil with green plants or trees in Ulaanbaatar.
- Therefore, this research is focused to study the heavy metal pollution in urban soil and identify the enrichment factor for each elements in order to prevent future pollution and to reclaim.
- Studied metals:

As, Cr,Pb, Zn, Ni, Cu, Co, V, Ca, Mn, Fe, Al

Materials and methods



Sampling sites location map

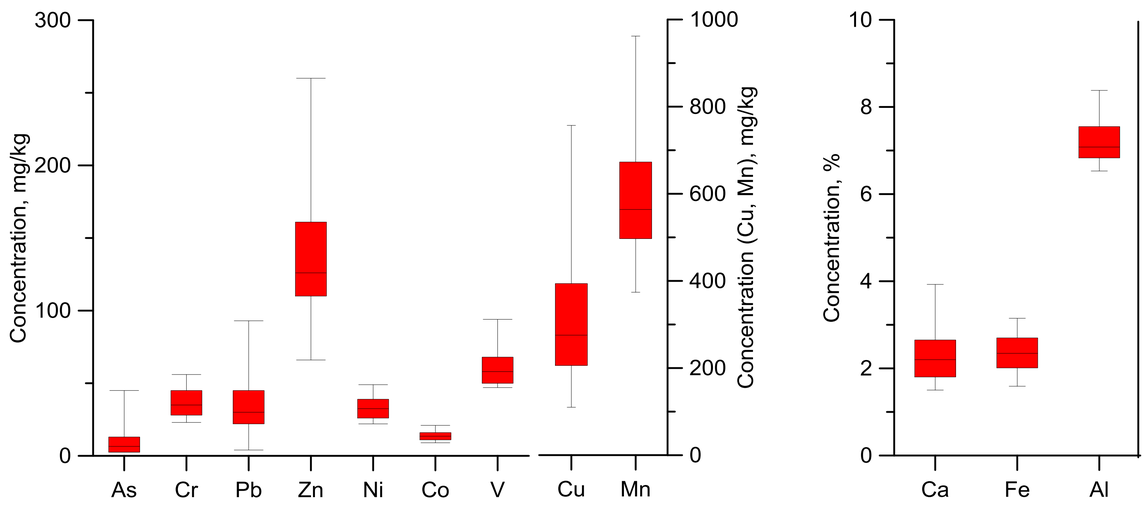
Sampling (22 points)

Dried (at room temperature)

Sieved (through 1mm)

Analysis
- Moisture content (dried at 105^{0}C)
- Organic matter (titration method)
- Grain size (aerometer method)
- Metals (ICP-OES)

Results and discussion



Concentrations of heavy metals in soil samples (Jul. 2015)

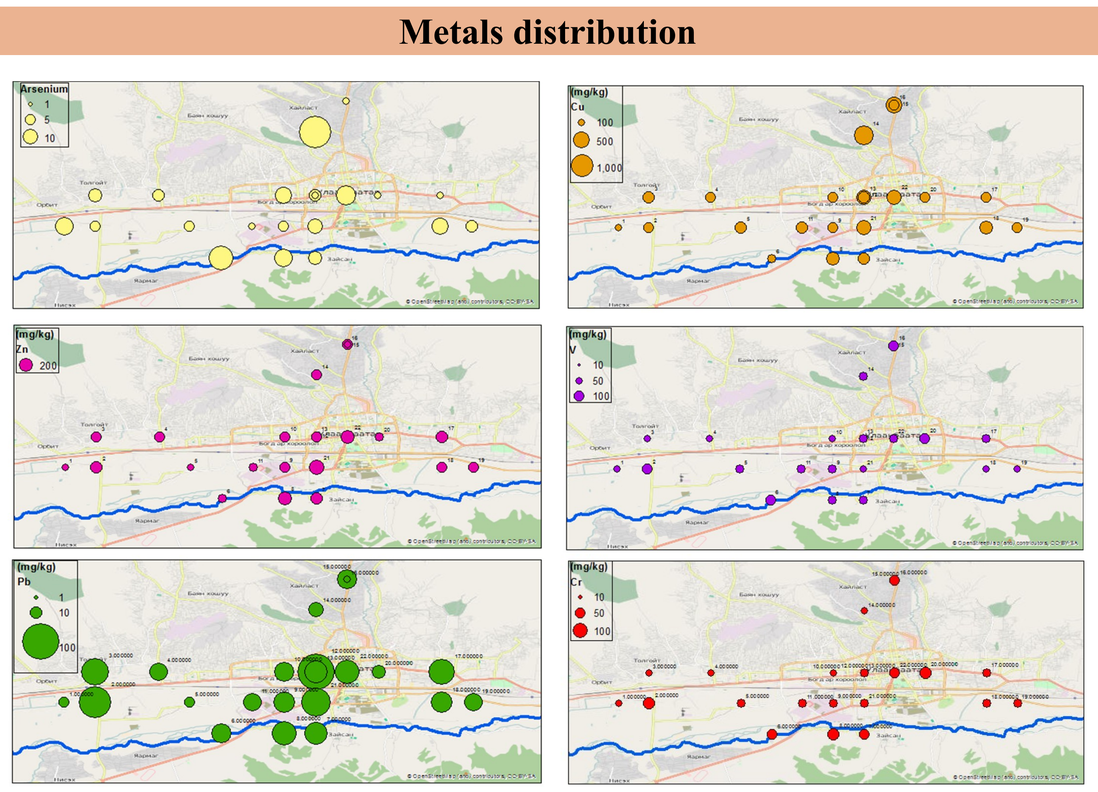
Crustal enrichment factor:

$$EFcrust = \frac{(X/Al)_{snow}}{(X/Al)_{crust}}$$

EF = 3–5 moderate enrichment
EF = 5–10 moderately severe enrichment
EF = 10–25 severe enrichment
EF = 25–50 very severe enrichment
EF > 50 extremely severe enrichment

	As	Cr	Pb	Zn	Ni	Cu	Co	V
Average	**8.4**	1.4	2.8	3.5	2.4	**29**	1.6	1.5
Stdev	**5.3**	0.30	1.9	1.4	0.55	**13**	0.16	0.14
Min	**2.5**	0.69	0.27	1.5	1.7	**12**	1.2	1.2
Max	**23**	2.1	8.4	7.8	3.6	**55**	1.9	1.8

Metals distribution



- Average concentration of As and Cu was exceeded by 2.2 and 3.1 times than Mongolian standards.
- Average crustal enrichment factor of Cr, Pb, Ni, Co and V was between 1.4 to 2.8, which suggests that these metals has minor enrichment.
- Pb enrichment factor in Bayanburd area, where main car repair shops located reached 8.4.
- Enrichment factor of Zn was 3.5 which is moderately enriched in urban soils.
- The average EF of As was 8.4. In western part of UB (site 14) was highest reaching 23.5. This area was located in ger district, one of the main sources for As can be coal burning.
- Cu was only metal that has been very severely enriched (EFavg =28.7) in urban soils. Same as As the highest EF was observed in site 14.

Comparison with references

City	Metals in soil (mg/kg)									Reference
	As	Cd	Cr	Cu	Ni	Pb	Zn	Co	V	
Warsaw	-	0.73	32.0	31.0	12.0	57.0	166.0	-	-	Manta D.S. et al., 2002
Stockholm	-	-	27.0	47.0	9.0	104.0	157.0	-	-	Poggio L., et al., 2009
Bangkok	-	0.29	26.4	41.1	24.8	47.8	118.0	-	-	Wilcke W., 1998
Manila	-	0.57	114.0	98.7	20.9	213.6	440.0	-	-	Manta D.S. et al., 2002
Hamburg	23.0	2.0	95.4	146.6	62.5	218.2	516.0	-	-	Manta D.S. et al., 2002
Mexico	-	-	117.0	100.8	39.8	140.5	306.7	-	-	Moller A., 2005
Beijing	6.2	-	-	-	-	-	-	-	-	Lu X., 2009
Denver	5.0	-	-	-	-	-	-	-	-	Reimann J., 2009
Ulaanbaatar	14.0	0.8	20.3	35.9	18.7	63.9	158.7	-	-	Batjargal et al., 2010
Ulaanbaatar	10.8	0.25	32.7	22.4	17.0	45.9	120.3	8.0	54.3	Kasimov et al, 2011
Ulaanbaatar	13.1	<5.0	47.3	308.1	35.7	36.8	148.8	15.3	74.7	This study, 2015
Mongolian standard	6.0	3.0	150.0	100.0	150.0	100.0	300.0	50.0	150.0	MNS5850:2008

Conclusion

- The urban soil in UB is relatively non polluted, only for As and Cu average concentration were above the soil standards.
- The crustal enrichment factors of each metals were different in all sites, nevertheless metals were moderately enriched in urban soil, except for As and Cu, which are extremely enriched.
- The main sites where metals enriched were in ger district-coal burning places, car repair vendors and industrial areas.

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