

LEAD IN THE URBAN ENVIRONMENT: CASE STUDY OF YEREVAN, ARMENIA

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Introduction

Among a large number of pollutants of modern multifunctional cities particularly hazardous is Pb because this element is widely spread, can migrate and accumulate in the environment (Steinnes, 2013), is largely used by a man (Lopez et al., 2015), and poses a threat to the health of humans emphasizing children (De Vries, 2007).

The research goal was to reveal peculiarities of Pb distribution throughout Yerevan and to implement human health risk assessment based on generalized outcomes of geochemical soil and dust surveys.

Methods

The contents of lead in the territory of Yerevan were investigated in the framework of geochemical soil, snow and leaf dust surveys implemented during 2011-2012. In soils Pb content was determined by X-ray fluorescence spectrometry, while Pb in snow and leaf dust: by atomic absorption spectrometry. Field and analytical works were implemented by SOP's in compliance with ISO, US EPA and national standards and guidelines.

To provide geochemical assessment of Pb in soils and dust the Pollution index (PI) was calculated and mapped implementing ArcGIS software. Children and adults health risk associated with Pb was calculated in accordance with a risk assessment model developed by US EPA (EPA, 1989; 2002). Dust calculations were done taking into consideration three major pathways of penetration into a human organism, for soils only ingestion pathway was considered (RAIS, 2014).

Results

Lead was found in soils and dust throughout the Yerevan, although the main source of lead - ethylated gasoline was forbidden in Armenia since 2001. PI values (Tab. 1) of Pb in urban soils ranges from 0.5 to 1150.9 with the mean of 22.9. PI values in snow and leaf ranges from 2.4 to 182.6 with the mean of 20.0 and from 2.5 to 22.6 with the mean of 6.7, respectively. Mean PI of Pb in snow is 8.5 times higher than in leaf. The latter could be a consequence of frequent temperature inversions and disturbance of active mixing of air masses throughout Yerevan.

In all 3 medium mean values of PI belongs to the high level of contamination ($PI > 3$, Sun et al., 2010). In addition, high level of contamination ($PI > 3$) was determined in 95.6% ($n=1296$) of soil samples, 95.8% ($n=23$) of snow and 88% ($n=22$) of leaf samples.

According to the results of multipurpose geochemical survey of soils, Pb was 1st in the geochemical series created by mean values of PI: $Pb_{(22.9)} > Hg_{(6.8)} - Zn_{(3.3)} - Cu_{(2.6)} - Ni, V_{(2)} - Cr_{(1.7)} - Mo_{(1.5)} - As, Ba_{(1.1)}$. Concerning the snow it was in 4th place: $Mo_{(657.6)} - Cd_{(28.4)} - Ag_{(27.8)} - Pb_{(20.0)} - Hg_{(17.0)} - Cu_{(9.7)} - Zn_{(3.6)} - Ni_{(1.2)}$, in leaf - 7th place: $Mo_{(579.8)} - Cd_{(155.9)} > Hg_{(33.5)} - Ag_{(26.8)} - As_{(22.8)} > Cu_{(7.4)} - Pb_{(6.7)} - Co_{(4.0)} - Zn_{(3.6)}$ (in brackets is given the mean values of PI). The share of Pb in mean intensity of poly-element pollution of soils exceeds 55%, whereas the analogous index for dust is significantly lower: 3% - for snow and 1% for leaf.

Table 1. Descriptive statistics of Pb (mg/kg) content in soils and dust in Yerevan

Parameter	Soil		Dust		Soil (PI)		Dust (PI)	
			snow	leaf			snow	leaf
N sample	1356	25	23	25	1356	25	23	25
Minimum	2.5	21.1	11.3	12.1	0.5	4.4	2.4	2.5
Maximum	5524.4	125.9	876.5	108.5	1150.9	26.2	182.6	22.6
Mean	109.9	68.5	96.2	32.4	22.9	14.3	20.0	6.7
SD	231	33.1	177.0	20.7	48.1	6.9	36.9	4.3

To compare Pb contents in all investigated medium, soil samples (n=25) which were spatially allocated with snow and leaf sampling sites were selected and observed separately (Tab. 1). In this case mean value of PI in urban soil was 14.3 (high contamination). The comparison results showed that mean contents of Pb decrease in the following range: snow dust - urban soil - leaf dust.

Health risk assessment demonstrated no health risk associated with Pb in snow and leaf dust, while in soils non-carcinogenic health risk to children was determined throughout Yerevan, and to adults - only in 4 sites.

Conclusion

Complex geochemical surveys of the territory of Yerevan were indicated that lead is priority contaminant of soils, snow and leaf dust almost in all city area. Pb mean contents PI values belongs to the high level of contamination in all mediums investigated but the non-carcinogenic risk associated with Pb contents was determined only in soils.

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