HUMAN HEALTH RISK ASSESSMENT IN IVANOVO REGION FROM SOIL CONTAMINATION

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The problem of environmental pollution by heavy metals (HM) and trace elements is very urgent respectively the problems associated with the implementation of environmental monitoring, assessment of the HM impact level on human health and the environment quality.

Heavy metals exist in all natural environments and frequently have a tendency to bioaccumulation. Their expressed toxicity and high level of the influence define the urgency of investigation of heavy metals migration and transformation in natural ecosystems. Soil is one of the major objects of heavy metals deposition. It has a significant storage capacity; it can absorb toxicants and keep them for a long time. Soil contamination is dangerous by itself, but more important is secondary contamination of other environments by metals from the soil.

The potential damage to human health makes it necessary to estimate environmental risk parameters. This work is devoted to the study of human health risk assessment from effects of soils contamination by heavy metals in the Ivanovo city and Ivanovo region. Within this work the calculation and analysis of the basic parameters of environmental risk were carried out. In addition, the magnitudes of the probability of adverse effects, loss in life expectancy and the the economic damage to human health and the environment were determined.

The object of the investigation is Ivanovo region situated at the interfluve of the Volga and Klyaz'ma rivers and has an area more than 22000 km^2. Sampling and analytical procedures were made according to standard techniques.

For the background monitoring (Fig.1.) throughout the region, the 45 sampling points were chosen from study region with an average distance between the points of 20 km. For the anthropogenic impact monitoring 41 sampling sites were separated around 9 large industrial towns (Teikovo, Ilinskoye, Furmanov, Privolzhsk, Rodniki, Vichuga, Kineshma, Shuya and Ivanovo).

Fig.1.Sampling map. Background monitoring

The complex analysis of pollutants content was carried out with the use of flame atomic absorption spectrometry (AAS) in Ivanovo and neutron activation analysis (NAA) in Dubna. The determination uncertainties were about 30% and 5% for AAS and NAA, respectively.

The factor analysis in combination with the construction of spatial distribution vector maps of the studied elements was used to identify possible sources of toxicants. The obtained results of factor analysis confirmed anthropogenic character of the pollution on the areas with high concentration of HM.

Average HM content in the soil samples was within the range of maximum permissible concentration (MPC) for HM (Table 1). However, the increased content in the soil near large industrial centers evidenced of their anthropogenic origin. The most samples around large industrial towns had a higher concentration than the background ones.

Table 1. Heavy metals content in soils of Ivanovo Region

HM	Mean	Min-Max	lbg	MPC_S (APC_S)	BG[1]	BG[2]
Cr	56.8	19.6-87.8	38.7	-	140	70
Mn	746	14.3-1610	343	1500	650	750
Ni	15.3	3.3-39.0	6.79	80	51	37.3
Co	7.21	1.5-11.2	4.48	-	7.2	15
Zn	39.9	10.5-71.5	23.0	220	49	74
As	2.94	1.07-7.51	1.81	2	-	-
Mo	0.62	0.19-1.07	0.43	-	1.5	0.5
V	34.1	3.13-62.4	19.5	150	72	-
Cu	6.43	0.2-20.0	1.59	132	23	24.9
Cd	0.028	0.002-0.167	ND	2	0.3	0.375
Pb	0.22	0.02-3.32	ND	32	19	30

[1]- Methodological guidelines for determining HM content in soils and plant products
[2]- Pilyugina M.V. Environmental biogeochemical monitoring: criteria, standards, factors

The calculation of parameters of environmental risk to human health was conducted for 4 groups: men, women, children and all adult population. The estimation of the environmental risk parameters was also performed.

The magnitude of the risk to human health was estimated as: probability of unfavorable events occurrence (carcinogenic (CR) and non-carcinogenic effects (HQ)), economic damage to human health (risks and average cost of living), loss in life expectancy (LLE)

The calculation of individual carcinogenic risk (CR) was carried out using data on the magnitude of exposure and the values of the factors of the carcinogenic potential (SF_a) and average daily lifetime dose (LADD) by the following formula:

$CR = LADD \cdot SF;$

The calculation of the risk of non-carcinogenic effects (HQ) was carried out using data on the average daily lifetime dose (AD) and reference dose (RfD) by the following formula:

$HQ = AD / RfD;$

The SF and RfD values are advisory and depend only on the nature of the toxicant and the method of its receipt.

The calculation of the loss in life expectancy (LLE) and the economic damage to health (R_{MO}) was performed by the following formulas:

$$LLE = (T_{cp} – A_{cp}) \cdot (HQ + CR);$$

T_{mean} – average life expectancy of the target population, (years), A_{mean} – the average age of the target group, (years);

$R_{MO} = LLE \cdot N \cdot ALC;$

N – number of people in the group; ALC – the average living costs, mln. €.

$$ALC = GDP_{RUS} / N_{RUS} \cdot T_{Mean}$$

The data showed significant level of risk to public health in the Ivanovo city and near 9 large towns of the Ivanovo region (Table 2). General toxic adverse effects are dangerous in the first place.

Table 2. Average risks of carcinogenic and non-carcinogenic effects in Ivanovo region

	HQ	CR	$R_{permiss.}$
Adults	$6.05 \cdot 10^{-3}$	$3.68 \cdot 10^{-4}$	$1.50 \cdot 10^{-4}$
Men	$6.03 \cdot 10^{-3}$	$3.62 \cdot 10^{-4}$	$1.66 \cdot 10^{-4}$
Women	$7.4 \cdot 10^{-3}$	$4.28 \cdot 10^{-4}$	$1.37 \cdot 10^{-4}$
Children	$3.27 \cdot 10^{-2}$	$1.24 \cdot 10^{-3}$	$1.50 \cdot 10^{-4}$
10^{-4}-10^{-3}-Unacceptable risk			
Carcinogenic effects -CR , Non-carcinogenic effects -HQ			

The average probability of developing of carcinogenic and non-carcinogenic effects amounts $6.05 \cdot 10^{-3}$, which is much higher than the level of acceptable risk (10^{-4}-10^{-3}).

For all population groups the calculated risk is unacceptable with high values of the loss in life expectancy (up to 2-3 years) (Fig. 2, 3) and damage health (up to 0.15 Mln. €) (Fig.4).

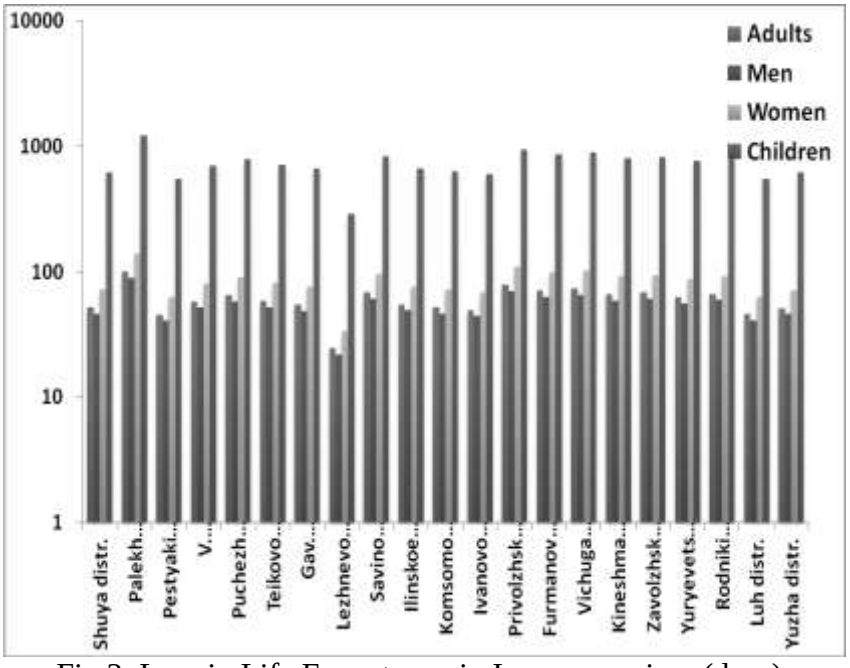

Fig.2. Loss in Life Expectancy in Ivanovo region, (days).

The significant decreasing of the values of risk to human health should be noted during the transition from urban areas to rural areas.

The result of factor analysis have showed that the main source of the elements under study in the Ivanovo region soil is the impact of trans-boundary emission from industrially developed territories of Yaroslavl and Kostroma regions (Fig.5).

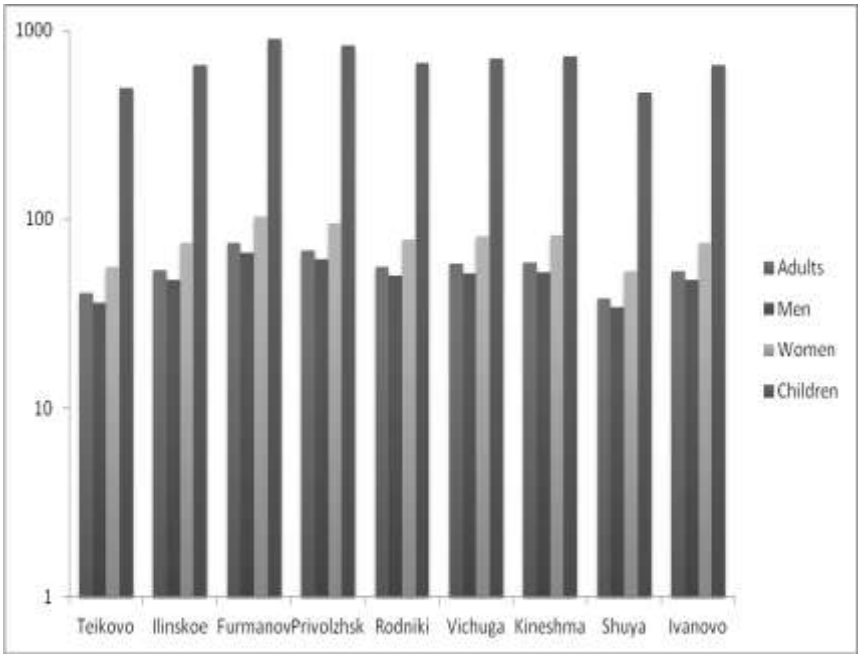

Fig.3. Loss in Life Expectancy near to large towns, (days).

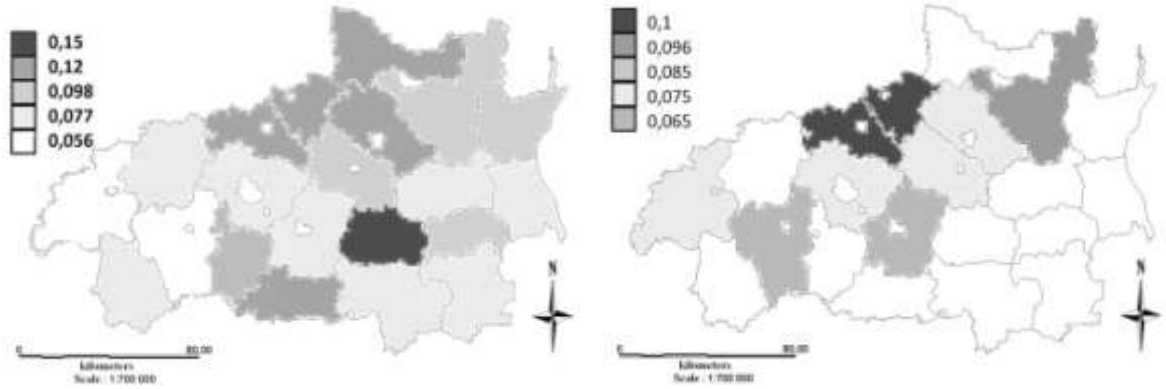

Fig.4. Economic Damage to Health in Ivanovo region and near to large towns. Mln. €.

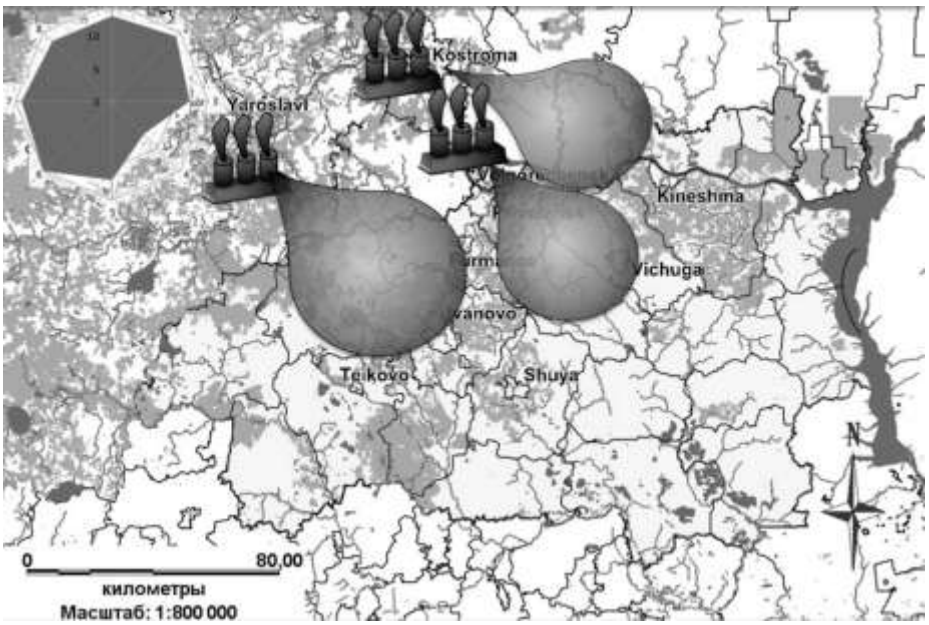

Fig 5. The impact of trans-boundary emission.

The main conclusions are:

1) results of calculation justified a significant human health risk values from the soil contamination. In some districts this fact is in a good agreement with environmental quality assessment results;
2) it was established that the risk data in selected sites around large cities and the risk level of Ivanovo region districts are coincided. It indicates an insignificant contribution to the level of pollution by cities;
3) main source of the elements under study in the Ivanovo region soil is the impact of trans-boundary emission from industrially developed territories of Yaroslavl and Kostroma regions.