ASSESSMENT OF HUMAN EXPOSURE TO HEAVY METALS IN SOIL AND HEALTH INTERVENTION PROGRAMMES IN COPȘA MICĂ

CAMELIA MICLĂUȘU[1]

[1]*PhD Student "Babeș-Bolyai" University" Cluj-Napoca*

Keywords: *exposure, heavy metals, Copşa Mica*

Abstract: *Copşa Mică has a pollution history, health problems being reported due to heavy metals exposure. Occupational exposure to lead (Pb) has led to instances of blood lead level (BLL) among the employees of the metallurgical unit. Currently, due to soil pollution, cases of blood lead level (BLL) among children have been reported, with BLL exceeding 8 times the blood lead reference value by the CDC. The purpose of this research is assessment of exposure to heavy metals in soil by ingestion pathway, considering adults and children. Results have shown much higher exposure doses for pica child and children than for adult. Because the contaminated areas are extended, the depollution measures are not applicable. In order to improve population health, it is considered appropriate to implement health programmes for decreasing or even stopping the population exposure to heavy metals in soil.*

INTRODUCTION

The first studies analyzing the population health of the pollution in Copşa Mică referred to the exposure of workers to high levels of Pb in the non-ferrous metallurgy plant I.M.M.N. (SOMETRA). According to Bardac D., 1999 (1), an analysis of occupational morbidity in the plant was carried out between 1968-1980. There were recorded 607 cases of occupational chronic saturnism, with saturnine colic frequently present (77 cases). In the category of occupational diseases, there were also chronic poisoning with As and Cd, and silicosis. Between 1981-1989, there were 1.247 cases of chronic occupational saturnism and between 1990-1998, there were 847 cases. The number of occupational exposure cases decreased significantly since 1995, when the activity of the metallurgical unit has been reduced. The conclusion was that the chronic effects were caused by exposure to permanent concentrations of atmospheric pollutants, and there was a relationship between the presence of atmospheric pollutants (Pb, Cd, Zn) and some chronic non-specific bronchopulmonary diseases: chronic bronchitis, asthmatic bronchitis, pulmonary emphysema.(1)

Nowadays, atmospheric emissions are significantly decreased, but they have generated soil pollution over time. In soil, heavy metals have long retention, between tens and thousands of years.(2) Thus, the main source of population exposure to heavy metals is contaminated soil.

A recent study on 200 children (age 2-11) showed that the BLL were 12.5-65 μg/dL.(3) BLL values have been statistically associated with certain behaviours such as children's habit of playing with soil, the absence of wet dust removal in homes and schools etc. In 2003, the assessment of lead exposure on a group of 89 children showed an average BLL of 45 μg/dL (4) and in 2008 an average of 39 μg/dL.(5) There was a decrease noticed in the average value of BLL comparing the level recorded in 2003, but still remains at a dangerous level that affects the health of children. In 2012, the Centers for Disease Control and Prevention – CDC (6) established the blood lead reference value for adults at 10 μg/dL and for children at 5 μg/dL. When determining the level of lead in children's blood, it was taken into account that children represent the population group with the highest susceptibility to exposure. It is noticed that in 2008, the average level of BLL in children of Copşa Mică was almost 8 times higher than blood lead reference value by the CDC.

According to the latest study in Copşa Mică (5), human exposure pathways of heavy metals are by ingestion of soil particles and dust, by ingestion of home-produced vegetables and inhalation of dust, the most susceptible being the children. Because of hand-to-mouth behaviour, children are susceptible to ingest quantities of heavy metals considerably larger than adults, so the absorption is greater. Combined with a lower body weight, it results that exposure dose are much higher than in adults. Within the group of children, a special category is distinguished - *pica child* - having specific behaviour. They ingest larger amounts of soil and the exposure to heavy metals is much higher for them.

Considering the remanence of heavy metals in soil and the fact that soil pollution is maintained moderately to high for Cd, Pb, and Zn (7), it results that the source of exposure to heavy metals is permanent in Copşa Mică. In order to improve the population health, especially children health, interventions are needed to alter some attitudes, behaviours, and practices that favour exposure.

AIM

The purpose of research is assessment of exposure to heavy metals in soil by ingestion pathway, considering 3 population groups: adults, children and pica child.

The assessment of daily exposure doses is made in order to substantiate future interventions for decreasing or even stopping population exposure to heavy metals in soil.

MATERIALS AND METHODS

For the calculation of the daily exposure dose of contaminants via ingestion exposure pathway, it was used a

[1]Corresponding author: Camelia Miclăușu, B-dul. Mihai Viteazu, Nr. 7/60, Sibiu, România, E-mail: eco_camelia@yahoo.com, Phone: +40769 628880
Article received on 28.06.2019 and accepted for publication on 22.07.2019
ACTA MEDICA TRANSILVANICA September;24(3):15-17

program of the Agency for Toxic Substances and Disease Registry (ATSDR) of the Center for Disease Control and Prevention (CDC), which is also used in the United States of America. Exposure doses were calculated for adults, children, and pica child, based on the concentrations of heavy metals in soil, that were analyzed in 2 research campaigns, in 2014 and 2018. Soil samples were collected from 20 households of Copșa Mică and 27 public areas (playgrounds, sports fields, kindergartens, schools, market-supermarket etc.). The analyzed metals being: Pb, As, Cd, and Zn. Daily Exposure Dose Equation is:

$$ED=(C \times IR \times EF \times BF \times CF)/BW \quad [mg/kg\ day^{-1}] \ (8)$$

Where: ED – exposure dose (mg/kg, day), C – contaminant concentration (mg/kg), IR – intake rate of contaminated medium (mg/day), EF – exposure factor (without a unit of measure), BF – bioavailability (without a unit of measure), CF – conversion factor (without a unit of measure), BW – body weight (kg).

To have an image of the spatial distribution of exposure doses in households and public areas (Copșa Mică), the Kringing interpolation method was used in the ArcGIS software.

RESULTS

The assessment of human exposure to heavy metals in soil by ingestion pathway has been done for adults, children and pica child. The analysis was conducted for household (2014) and public areas (2018). For the entire city, one average exposure dose was calculated for each metal.

Table no. 1. The average exposure doses to heavy metals in soil by ingestion pathway, in households (mg kg^{-1} day^{-1})

	Adult 70 kg (100 mg day^{-1})	Child 1-6 years old, 16 kg (200 mg day^{-1})	Pica child 1-6 years, 16 kg (5000 mg day^{-1})
Pb	0.00186	0.016348	0.408704
As	0.000066	0.000576	0.014393
Cd	0.00004	0.00036	0.00923
Zn	0.00335	0.02937	0.73444

Table no. 2. The average exposure doses to heavy metals in soil by ingestion pathway, in public areas (mg kg^{-1} day^{-1})

	Adult 70 kg (100 mg day^{-1})	Child 1-6 years, 16 kg (200 mg day^{-1})	Pica child 1-6 years, 16 kg (5000 mg day^{-1})
Pb	0.00417	0.03650	0.91253
As	0.00028	0.00249	0.06220
Cd	0.00007	0.00061	0.01524
Zn	0.00402	0.03514	0.87844

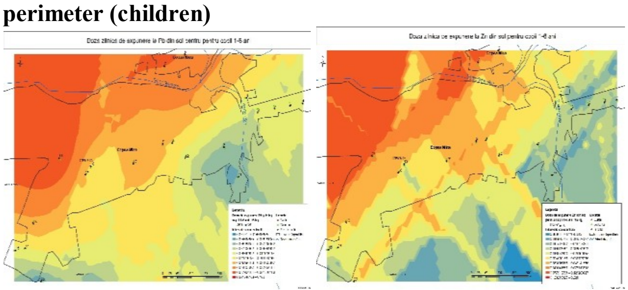
A summary analysis of the average exposure doses shows that:

- for all metals, the group of pica child, has an average exposure doses 218.7 times higher than for adults and 25 times higher than for children;
- for all metals, children have an average exposure doses 8.7 times higher than for adults;
- for Pb in public areas, the average exposure doses are 2.2 times higher than the average exposure doses in households;
- for As in public areas, the average exposure doses are 4.3 times higher than in households;
- for Cd in public areas, the average exposure doses are 1.65 times higher than in households;
- for Zn in public areas, the average exposure doses are approx. 1.2 times higher than in households.

It can be noticed that in public areas the exposure doses are significantly higher than the exposure doses in households perimeter. Both children and adults are more exposed in public areas. Future health intervention programmes in Copșa Mică should be focus on the most susceptible population to exposure - children and public areas frequented by them: playgrounds, sports fields, kindergartens, schools etc.

For households, where adults and children are exposed for a long time, using Kringing interpolation, distribution maps of daily exposure doses were created. For children, exposure maps to Pb and Zn in the soil are presented, indicating that for As and Cd, they are similar.

Figure no. 1. Distribution maps of exposure doses, by ingestion pathway to Pb and Zn in the soil of households perimeter (children)



The highest values of exposure to heavy metals in soil are recorded in the following areas of Copșa Mică:

- in the North-East of the city, in the Târnăvioara neighbourhood;
- in the East–South-East of the industrial platform, the neighbourhood with Muncitorilor, Nicovalei, Fierarilor streets;
- in the South of the industrial platform (the area of Laborator neighbourhood).

DISCUSSIONS

Concentrations of heavy metals in soil are high in Copșa Mică, resulting high exposure doses especially for the group of children with the pica child as a subgroup. Assessment of exposure doses has shown higher levels in public areas than in households. The children are exposed to high levels of heavy metals in public areas such as playgrounds, sports fields, kindergartens, schools, supermarkets etc. The exposure of children is also occurring within households, but in playgrounds they have frequent behaviours that favour exposure, such as passing objects and dirty hands to mouth, playing at the surface of the soil and direct ingestion of the soil.

Regarding adults, since the metallurgical unit drastically reduced its activity, the occupational exposure is significantly reduced, the main problem being related to the source of exposure in the soil.

Distribution maps of exposure doses, by ingestion pathway to Pb and Zn in the soil of households perimeter have revealed critical areas in some neighbourhoods - such as Târnavioara, where the quality of living visually appreciated is poor. Here, the dominance of the population with a low living standard is obvious, the most vulnerable population group being well represented (the children).

Because extended areas are affected by pollution, green reconstruction is not feasible. An appropriate solution is considered the one proposing measures to decrease or stop exposure in order to achieve population health improvement. The main measures to be applied should be focus on:

- children, in functional areas with the highest daily exposure doses (playgrounds, kindergartens, schools, sports fields etc.);
- adults, in functional areas where they are frequently exposed: in their own households and in public areas.

CONCLUSIONS

According to the Public Health Assessment Guidance Manual (8), Cap. 9, developed by the Agency for Toxic Substances and Disease (ADSDR), health intervention programmes must be developed and implemented after the health risk assessment. The main measures must refer to health advices for decreasing or stopping exposure, health education, and health surveillance studies.

Based on the results of present study, health intervention programmes should be targeted at children in order to reduce exposure in public areas and households. This involves measures aimed to change behaviours that favour the ingestion of soil and dust particles: hand and toys washing, administration interventions at playgrounds and kindergartens etc.

For adults, occupational exposure became a secondary issue. This means health intervention programmes must be targeted to changing attitudes, behaviours and practices that favour exposure such as: health education (hygiene), wet cleaning in households, abandonment of home-produced vegetables and watering gardens from the underground water source, stopping the marketing of local food plants etc.

At the administrative level, health intervention programmes should focus on measures implemented in public areas such as sanitation and street sweeping and washing, decreasing uncovered land areas who favouring the suspension of surface dust particles, grassing, pavement, asphalting and irrigation of green spaces to prevent dryness etc. Knowing the children's tendency to play at ground level, sandboxes can be arranged for playgrounds and kindergartens, brought from controlled sources and regularly changed.

It is important to take into account the residential areas where the highest exposure doses were recorded in 3 neighbourhoods: in the South of the industrial platform (Colonia Laborator, with blocks), Târnăvioara and the neighbourhood of the East-South-East of the industrial platform (with Muncitorilor Street, Nicovalei streets etc.). Another thing to take into account is that in some areas with high exposure doses to heavy metals in soil, population has a quality of life below the community average. Here, the group of children is well represented, and the health intervention programmes must be addressed properly to the cultural and educational level of the community.

Health intervention programmes should be promoted at the administrative level, through public information, in kindergartens and schools, the way of communication being appropriate to the public to whom it is addressed. Monitoring of results and their perpetuation should be ensured by monitoring health indicators in target population groups, for example by regularly measuring the BLL in children and adults.

Future implemented programmes and periodic analyzes of health indicators (BLL) should provide results that establish strategic decisions for public health in Copșa Mică.

REFERENCES

1. Bardac D. Copșa Mică. Elemente de monografie medicală și socială. Vol. 1. Casa de presă și editură Tribuna; 1999.
2. Kabata-Pendias A. Trace elements in soils and plants, CRC Press, Inc. Boca Raton, Florida, USA.: Chapter 4; 2001.
3. Gurzău E., Bardac D. Evaluarea riscului comunitar asociat expunerii la plumb și poluanți iritanți în zona Copșa Mică, județul Sibiu. Vol. I. Editura Mira Design Sibiu; 2002
4. Neamțiu I, Bardac D, Surdu S, Gurzău E, Gurzău AE, et al. Evaluarea riscului comunitar asociat expunerii la plumb și poluanți iritanți în zona Copșa Mică, județul Sibiu. Editura Mira Design Sibiu; 2003.
5. Gurzău E, Neamțiu I. Experimentarea și optimizarea modelului privind distribuția spațială și temporară a pesticidelor și metalelor grele în factorii de mediu din zonele Săliște și Copșa Mică. Ed. Universității Lucian Blaga Sibiu; 2010
6. Centers for Disease Control and Prevention. Low Level Lead Exposure Harms Children. A Renewed Call for Primary Prevention; 2012; Retrieved 2014.
7. Lăcătușu R. Contributions regarding heavy metals flow within soil-plant-animal system in polluted areas. Acta Metallomica. 2014;XI(1):73-88.
8. Agency for Toxic Substances and Disease Registry. Public Health Assessment Guidance Manual. Apendix G: Calculating Exposure Doses; 2005.
9. Muntean E, Muntean N, Mihăiescu T, Duda M. Heavy Metal Contamination of Soil in Copșa Mică Area. ProEnvironment 6; 2013. p. 469-473.
10. Tchounwou PB, Yedjou CG, Patlolla AK, Sutton DJ. Heavy Metals Toxicity and The Environment. National Institute of Health – PA. 2014;101:133–164. doi:10.1007/978-3-7643-8340-4_6.