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INGESTION OF LEAD DUE TO THE CONSUMPTION OF DRINKING WATER FROM PRIVATE WELLS IN FOUR RURAL AREAS FROM BAIA MARE – ROMANIA METROPOLITAN AREA

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Abstract

The ingestion of high levels of heavy metals through drinking water intake can lead to chronic diseases such as renal failure, liver cirrhosis and chronic anemia. The present study evaluates the lead content in thirteen private wells from four rural areas located in Baia Mare (NW Romania) metropolitan area. Based on the lead concentration, the daily intake rate of Pb was calculated for the female, male and children who use these water sources as drinking water supplies. The daily ingestion rate of lead due to water consumption was considerably higher for the inhabitants from Tăuţii de Sus (0.05 – 0.21 µg/day/person) than for the inhabitants from the other villages (<0.08 µg/day/person).

Key words**:** *daily ingestion rate, drinking water, exposure, lead*

INTRODUCTION

Due to the well-known toxicity and low biodegradation, as well as the threat to the environment and public health, lead is one of the heavy metals which has been widely studied in various environmental and biological compartments [1], [5], [13]. Ingestion of drinking water, vegetables and fruits contaminated with lead represent the main ways in which this element enters the human body. Once entered into the body, it is a cumulative toxicant that is deposited especially in bone and fat tissues and can affect multiple body systems, including the neurological, haematological, gastrointestinal, cardiovascular and renal systems, by causing different diseases, especially cardiovascular, kidney, nervous system, blood or bone diseases [14].

Children, especially under 6 years, represent the most vulnerable category and even relatively low levels of exposure can cause serious and sometimes irreversible neurological damage.

The main anthropic sources of lead are the mining and smelting activities. The present study was conducted in Baia Mare area, one of the important mining areas from Romania. The mineral assemblages from Baia Mare area include native elements (Au, Ag, Cu, As, S), sulphide minerals (pyrite, chalcopyrite, arsenopyrite, sphalerite, galena, stibnite) sulphosalts (tetrahedrite, jamesonite, semseyite, pyrargyrite) and tungstates (wolframite, scheelite), together with quartz, clay minerals, adularia, carbonates, rhodonite and barite as gangue minerals [9]. The mining of gold-silver, lead-zinc and copper ore deposits has been the main economic activity for many centuries, but its decline after 1990 created serious economic, social and environmental problems. The soil in Baia Mare mining area is contaminated especially with lead, copper, zinc and cadmium, as a consequence of the emission and dispersion of pollutants during the mining and post-mining activities, as well as the ore processing industry or tailings storage [2], [4], [6], [8], [11]. There are few recent data [3], [10] regarding the presence of heavy metals in drinking water from the wells in the area of Baia Mare. The main objectives of the present study were: (1) to investigate the presence of lead in thirteen private wells located in Baia Mare area, and (2) to evaluate the possible health effects to the residents caused by lead

uptake via water ingestion, by calculating the daily intake rate.

MATERIALS AND METHODS

The drinking water samples were collected from thirteen private wells, located in four villages from Baia Mare metropolitan area (Tăuții de Sus, Satu Nou de Sus, Bozânta Mare and Bozânta Mică) (Fig.1). The samples were collected in July 2014.

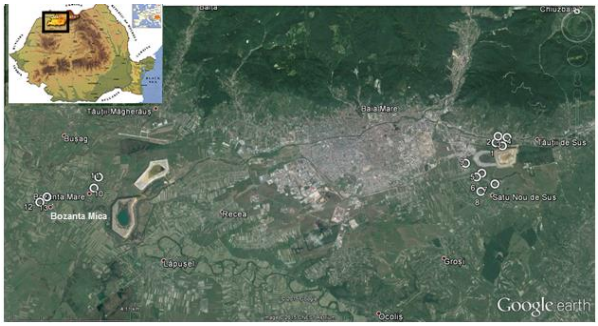

Fig. 1. The location of the sampling points.
Source: Google earth.

The water pH was measured *in situ* using a portable multiparameter (WTW Multi 350i).
The water samples collected for lead analysis were sampled in polyethylene bottles, filtered (0.45 µm) and acidified to a pH ≈ 2 (with HNO_3 65%). They were stored at dark and at cold (4ºC) and analysed within 48 hours from sampling. The lead content was analysed in the laboratory by Atomic Absorption Spectrometry (AAS, ZEENIT 700 Analytik Jena).
The potential chronic risks associated with the exposure to lead by water consumption were evaluated by calculating the daily intake rate (DIR) (µg/day) [12] using the following formula:

$$DIR = \frac{C \times I_R}{BW}$$

where, C is the lead concentration in water sample (mg/l); I_R is the water ingestion rate (l/person/day); and BW is the average adult/child body weight (kg).
A questionnaire-based survey was performed during the water sampling. The questionnaire acquired the basic information regarding water ingestion rate, number of family members, their age, and average weight.

RESULTS AND DISCUSSIONS

The analysed water samples proved to be slightly acidic to neutral, having the pH between 6.1 and 6.9. As it is shown in Fig. 2, most of the samples had the pH close to 6.5, which is the limit (6.5 – 9.5) imposed by national legislation for drinking water. The two wells from Bozânta Mare village and one of the wells (13) from Bozânta Mică village proved to have the pH lower than the limit imposed by national legislation. Such low levels of pH can enhance the heavy metals solubility.

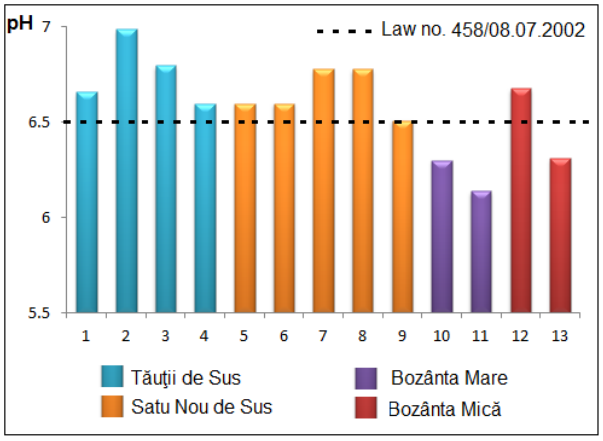

Fig. 2. pH value for the investigated wells.
Source: Own calculation.

The lead content of the analysed private wells ranged between 2.2 and 12.9 µg/l. With the exception of one well (no. 3 from Tăuţii de Sus village), the investigated wells had the lead content below the maximum permissible limit (10 µg/l) imposed by national legislation as safe limit for drinking water. The high level of lead from sample no. 3 is the consequence of the well location in the close vicinity of the "Aurul" tailing pond from Tăuţii de Sus. Because of the high mobility in soil, lead can infiltrate from the tailing pond into phreatic water leading to ground water contamination.
Similar results were obtained in the study made by Gurzău et al., 2012 [10], where extremely high levels of lead (up to 2800 µg/l) were detected in the close vicinity of the tailings ponds from Bozânta Mare and Bozânta Mică, while in the private wells from the two villages, lead was detected only in one sample (7.7 µg/l) being lower than 1 µg/l for

the rest of the analyzed wells [10].

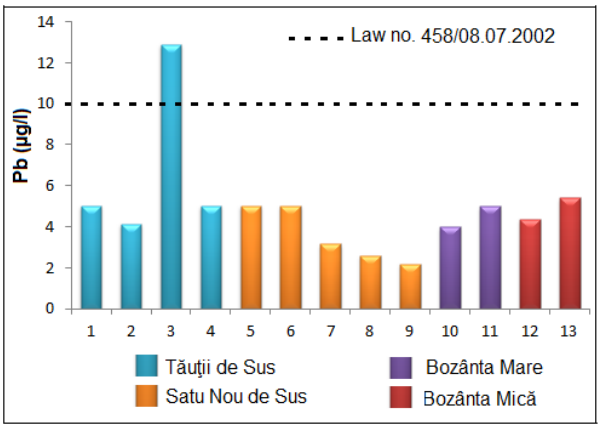

Fig. 3. Lead content in the analysed water samples, comparing to maximum level set by national legislation for drinking waters.
Source: Own calculation.

The daily intake rate (µg/day per kg body weight) was estimated based on the daily consumption rates of water from the investigated wells and the lead con2centrations in water samples.
A questionnaire-based survey was performed on 50 residents, out of which 42% were males (17% from 18 to 29 years old, 28% from 30 to 49 years old, and 55% from 50 to 73 years old), 46% were females (12% from 18 to 29 years old, 35% from 30 to 49 years old, and 53% from 50 to 78 years old), and 12% were children (between 3 and 13 years old). The average weight was 75 kg for males (ranging between 56 and 88 kg), 67 kg for females (ranging between 53 and 84 kg), and 34 kg for children (ranging between 12 and 45 kg). Based on the questionnaire information, the average intake of water from the monetarised wells was 0.8 l for adults, both female and male and 0.55 l for children.
The estimated daily intake rates (µg/day per kg body weight) of lead caused by water ingestion are presented in Fig. 4. The present study proved the high contribution of water ingestion to Pb intake, for the inhabitants from Tăuţii de Sus village.
The intake of Pb caused by the water ingestion from private water supplies in Tăuţii de Sus village ranged between 0.05 and 0.21 µg/day/kg body weight, comparing to the other investigated villages, where the lead intake 0.08 µg/day/kg body weight.

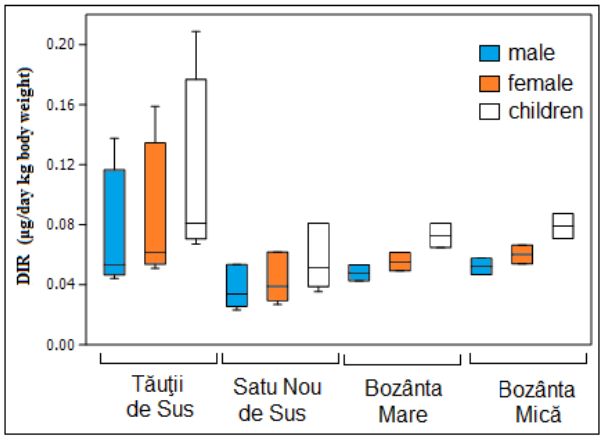

Fig. 4. The estimated daily intake rate (DIR) (µg/day per kg body weight) of lead via water ingestion
Source: Own calculation.

The tolerable daily intake for Pb is 3.57 µg/day/kg body weight, value which was recommended by FAO-WHO (2001) [7]. The lead intake caused by water ingestion from the private wells, represents a percentage of 3% (Tăuţii de Sus), 1.3% (Satu Nou de Sus), 1.2% (Bozânta Mare) and 2% (Bozânta Mică) from the tolerable daily intake for Pb.
The results showed that the DIR was higher for female than for male. The DIR was reported as µg of Pb daily ingested by a person per kg body weight, as a consequence due to the lower body weight of female the DIR was higher. For all the investigated villages, the DIR was higher for children than for adults, because in their case the ingested dose was reported to a lower body weight. The continuous usage of private wells from Tăuţii de Sus village, especially no. 3, as drinking water supplies represents a high risk for the inhabitants' health, especially for their children. Lead is a toxic metal, potential carcinogenic to humans; the toxic effects of Pb focus on the liver, kidneys, spleen and lung. As a consequence, in order to decrease the lead intake, the inhabitants from Tăuţii de Sus village should stop or reduce the use of private wells as drinking water supply. These water sources must be carefully monetarised because even at low levels, lead may cause a range of health effects including behavioural problems and learning disabilities.

CONCLUSIONS

The analysed water samples were slightly acidic to neutral, having the pH between 6.1 and 6.9. Three samples had a lower pH than the limit imposed by national legislation (6.5 – 9.5).

The lead level detected in the analysed samples ranged between 2.2 and 12.9 µg/l. In one of the wells from Tăuţii de Sus village, located in the close vicinity of the "Aurul" tailing pond, the lead content exceeded the maximum permissible limit imposed by national legislation.

The DIR of lead due to water ingestion was considerably higher for the inhabitants from Tăuţii de Sus than for the inhabitants from the other villages. For all the investigated villages, the DIR was higher for children than for adults.

Because of the high level of Pb, the consumption of drinking water from source no. 3 from Tăuţii de Sus village must be stopped or considerably restricted, because is a real threat for residents health.

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