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Research Paper

Public Health Assessment of Heavy Metals and Cyanides Exposure in Baia Mare Area

Health Care

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ABSTRACT

Exposure to heavy metals was associated with health outcomes such as impaired development, cancers, kidney damage, cardio-vascular diseases.

An evaluation was performed in order to assess the levels of exposure to heavy metals and cyanides in a population group living in the mining area of Baia Mare. Biological samples (blood, urine) were collected from the study participants living in the area and lab analyses were performed to measure the levels of the biomarkers of exposure to heavy metals and cyanides, in the biological fluids. An environmental health questionnaire was applied to the study participants. Higher than normal levels of biomarkers of exposure were measured in the investigated population sample, indicating that exposure to heavy metals continues and may increase in the absence of coherent and efficient policy actions.

INTRODUCTION

Along time, the production of chemicals kept increasing and the emissions rose consequently. One of the industries that releases important amounts of contaminants into the environment is mining (Gurzau et al., 2012). Once released in the environment, the metals in particular, tend to accumulate and persist there for decades. (Nriagu, 1996)

Human exposure to heavy metals (arsenic, lead, cadmium, mercury) as a result of environmental contamination generated by the industrial processes and products, has become a serious public health issue that has risen dramatically, worldwide, in the last decades (Jarup, 2003; Caussy et al., 2003).

The potential for adverse health effects of the heavy metals is well documented and the chronic exposure can cause symptoms such as impaired cognitive, motor, and language skills; learning difficulties; nervousness and emotional instability; insomnia, nausea and lethargy that may often develop slowly over time and sometimes may be difficult to be associated with heavy metals exposure but more with other health conditions (Ferner, 2001; Committee on Environmental Health, 2003). Chronic symptoms are frequently associated with excessive accumulation when heavy metals are not metabolized by the body and the toxics remain in the soft tissues (LaDou, 2004).

The main route of exposure to toxics in general and heavy metals in particular, are the oral exposure through food, water, air, the dermal exposure by absorption through the skin when they come in contact with the skin when working in agriculture and in manufacturing, pharmaceutical, industrial, or residential settings (International Labor Organization, 1999). The inhalation route of exposure is most common for the industrial environment (Dupler, 2001) while the oral route of exposure is the most common route of exposure in children. (Roberts, 1999; Gurzau et al., 2011; Surdu et al., 2006)

MATERIALS AND METHODS

Study area included Baia Mare, located in the western part of Maramures County, and two villages in the surroundings (Bozanta and Sasar).

Questionnaire survey - A questionnaire based interview was conducted with the study participants, collecting information on age, gender, level of education, workplace, occupation, household, perception on the indoor and outdoor pollution, health status history (diseases diagnosed during lifetime, respiratory symptoms and other symptoms specific to the exposure to hazardous substances such as heavy metals and cyanides).

Biological sampling and analysis - We have enrolled in the study, a number of 65 participants, who all agreed to participate by signing an informed consent and from whom we have collected blood and urine samples to be tested for heavy metals and cyanides. All the analysis were performed on samples that have previously entered a chemical digestion process.

Lead in blood and cadmium in urine were analyzed using atomic absorption spectrometry with graphite furnace. The device used is a ZEENIT 700P. To measure lead in blood, a Zeemann background correction systems and D2-lamp background correction together with a mix of palladium nitrate as matrix modifier, were used. The calibration curve was drawn based on the absorbance measured for aqua solution of lead in five concentrations 0, 10, 20, 40, 60µ/l lead. For each sample, three separate readings were done and the value reported was the average of those readings.

For analyzing cadmium in urine, the calibration through standard addition method was used, in order to eliminate the errors due to matrix. The urine samples were diluted 1:5 and put into the graphite furnace together with the matrix modifier, palladium nitrate 1%, and with ammonium nitrate 0.5 %. The concentration of metal in the sample was read on the calibration curve.

Mercury in blood and arsenic in urine were analyzed using the atomic absorption spectrometry technique with hydride generation (in case of mercury - the cool vapors technique using as reducing agent, sodium borohydride 0.3% and as carrier solution, nitric acid 5%). The device used is a ZEENIT 700P combined with a HS A60 hydride generator.

The method for determining the total arsenic in urine was based on the measurement of the sample metal ion content using atomic absorption spectrometry with hydride generation. In the atomic absorption spectrometer reaction column, the sample was reacting with sodium borohydride in an acid medium and formed a volatile metal hydride. The volatile metal hydride was atomized in a quart cell heated at 960°C and samples absorbances were measured.

Thiocyanates in urine - Thiocyanates, the metabolites of hydrogen cyanide and its compounds, are chemically reacting with ferric nitrate generating a measurable red- brown colorimetric chemical compound, ferric tiocyanate.

In case of all analysis, for quality assurance/control, the recovery rate was calculated by determining the concentration in the same sample, to which a well known standard concentration was added. Also the accuracy of the analysis was verified by using commercially available quality control reference materials.

Data analysis - The data collected was entered, cleaned and processed using Excel and Stata statistical package. The statistic procesing of the data used univariate liniar regression models.

RESULTS

The investigated population sample included 65 subjects, from Baia Mare area.

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The average value with standard deviation, maximum and minimum values of the concentrations measured in biological fluids for cadmium, arsenic, lead, mercury and thiocyanates are shown in Table 1.

Cadmium measured in the urine samples colected from the study participants living in Baia Mare area, ranged between 0.015-3.646 µg/l, with an average value and a standard deviation of 0.546±0.679 µg/l. Arsenic measured in the urine samples within the investigated subjects, ranged between 0.08-19.51 µg/l, with an average value and a standard deviation of 6.79±3.91 µg/l.

Blood lead levels in our population sample, ranged between 0.44-11.63 µg/dl, with an average value and a standard deviation of 3.03±2.11 µg/dl. Mercury measured in the blood samples colected from our study participants, ranged between 0.60 -7.47 µg/l, with an average value and a standard deviation of 2.70±1.42 µg/l.

Urinary thiocyanates had values that varied between 0.1-2.47 mg/l, with an average value and a standard deviation of 0.66±0.39 mg/l.

Table 1. Mean, standard deviation, maximum and minimum values of biomarkers of exposure to heavy metals and cyanides measured in a population sample in the study area

Biomarkers of exposure	Average	Standard deviation	Minimum	Maximum
Cadmium in urine (µg/l)	0.546	0.680	0.015	3.646
Arsenic in urine (µg/l)	6.794	3.916	0.08	19.514
Blood Lead (µg/dl)	3.039	2.116	0.4402	11.63
Mercury in blood (µg/l)	2.706	1.422	0.602	7.477
Thiocyanates in urine (mg/l)	0.661	0.395	0.1	2.47

Table 2. Liniar regression models testing the correlation between the biomarkers of exposure to heavy metals and cyanides measured in biological fluids and specific symptoms and diseases that can be associated to those exposures

Level of cadmium in urine	Coefficient	Std. Error	t	p>|t|	95% Confidence Interval	
Fancony syndrom	-0.034	0.167	-0.202	0.841	-0.367	0.300
Hypertension	-0.764	0.277	-2.755	0.008	-1.318	-0.210
Kidney disease	-0.676	0.244	-2.769	0.007	-1.165	-0.188
Level of arsenic in urine						
Skin pigmentation changes, hyperkeratosis	0.026	0.843	0.031	0.975	-1.658	1.710
Arrhythmia	-2.855	1.653	-1.728	0.089	-6.158	0.447
Muscle pain, numbness	-0.935	0.613	-1.525	0.132	-2.160	0.290
Level of lead in blood						
Hypertension	-3.135	0.823	-3.809	0.000	-4.781	-1.489
Irritability, hyperkinesia, impaired concentration, attention deficit, abdominal pain, nausea, anaemia, constipation	0.227	0.410	0.554	0.582	-0.592	1.046
Level of mercury in blood						
Kidney disease	-0.434	0.540	-0.804	0.424	-1.513	0.645
Erythema (rash) with itching and scaling of the skin on nose, hands and legs, acrodynia	-0.133	0.361	-0.367	0.715	-0.854	0.589
Irascibility, tremor emotional changes, confusion, depression, mental disturbances, memory loss	-0.092	0.313	-0.294	0.769	-0.718	0.533
Level of thiocyanates in urine						
Difficulty breathing, chest pains, nausea, headaches	-0.093	0.057	-1.624	0.109	-0.208	0.022

The statistic analysis using univariate liniar regression models, of a potential relationship between the levels of biomarkers in the biological fluids (heavy metals in blood, thiocyanates in urine) and certain symptoms and diseases associated with the exposure to heavy metals and cyanides, investigated via a questionnaire, did not show any statistically significant correlation between the levels of the biomarkers in urine and blood and the symptoms and/or diseases declared in the questionnaire.

The correlation coefficient, t test results, p value are shown in Table 2.

CONCLUSIONS

The levels measured in the blood or urine of certain biomarkers of exposure to heavy metals within a population group living in the study area, were below the reference limit that separates normal from pathological conditions with few exceptions (one subject in case of blood lead and mercury levels and three subjects in case of urinary cadmium showed values of those biomarkers higher than the reference limit that separates normal from pathological conditions) while for the biomarker of exposure to cyanides and hydrogen cyanide (thiocyanates), all the measured values were below the reference limit. The statistic analysis testing a potential relationship between the levels of biomarkers in the biological fluids and certain symptoms and diseases associated with the exposure to heavy metals and cyanides did not show any statistically significant correlation between the levels of biomarkers and the investigated outcomes.

The high levels of cadmium and lead in the underground water in Baia Mare area pose health risks on the population groups residing there and must be addressed through coherent and efficient policy actions, to clean the area.

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