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ENVIRONMENTAL IMPACT OF HEAVY METALS ON THE BLOOD CELLS IN PROFESSIONALLY EXPOSED WORKERS

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Abstract. Aims of the study is to explain and research the effects of the heavy metals (lead, zinc and cadmium) on erythrocytes and leukocytes in miners with different work experience or exposure. The results and conclusions are made based on a three-year period of continuous testing on 120 miners, as professionally exposed workers. We confirmed that the miners long been professionally exposed to heavy metals, in the blood have an increased content of heavy metals (lead, zinc and cadmium) and they have affect the change of some haematological parameters, resulting in the emergence of certain diseases with complex etiology. The multidisciplinary elaboration of the topic suggests the need for a more serious approach to this important phenomenon, impact of heavy metals on exposed workers.

Keywords: heavy metals, professional exposure, blood cells, miners.

AIMS AND BACKGROUND

The current topic in the field of occupational exposure is subject of great interest of many research workers in the world[1–6]. Considering the fact that today urban living is in direct correlation with the strong growth of many industries, the cytology and histology as sciences often as an object of the analysis take the influence of various chemical compounds on changing the structure and number of the blood cells[1,2,7,8]. From the ecotoxicology point of view, particular interest in this paper is presented to toxicological view, which we can analyse cytologically. In this cytological monitoring study, the interest is chronic exposure to occupational exposed workers (miners) at constant low dose of potentially genotoxic agents. In that context of special interest is to determine the influence of various heavy metals (lead, zinc and cadmium) as silent, but at the same time the strongest, factors for structural and numerical exchanges in the blood cells. Knowing the structure of various heavy metals, all of the analysis is to examine the impact of these heavy metals on the number and structure of the blood cells (erythrocytes and leukocytes), by determination of their concentration in blood serum of the miners of different ages and with different working experiences. Nicotine, and other factors as an additional chemical agent enhances the intensity of such changes, and for that reason, its influence was examined from the intensity and type of changes of the bloods in this category of respondents[9,10]. Aims of the study are to explain and research the effects of the heavy metals (lead, zinc and cadmium) to organism especially to erythrocytes and leukocytes in miners with different work experience or exposure to heavy metals. This is the biological monitoring as a set of activities that identify and quantitatively determine the concentrations of heavy metals, their primary or secondary metabolites[6] in biological forms such as blood in the specified category of professionally exposed workers.

EXPERIMENTAL

This study reports the results of a three-year biomonitoring of miners ($N = 120$) occupationally exposed to heavy metals. All of them voluntarily agreed to participate in the research refereed by ethical committee and in accordance with the Declaration of Helsinki (1983). The survey questionnaire was used, which is a standardised tool for this research and provides for grouping and processing of data and used standardised research instruments such as questionnaires and interviews of a larger group of subjects in order to get a clearer and richer examination of the data necessary for further analysis. 9% of the miners are 30 years old, 42% are on the ages between 30 and 45 and the others 49% are on the ages between 45 and 60. Considering the reference values for erythrocytes as $(4.8–5.8) \times 10^{12}$/l (Ref. 11) in our research we concluded that 72% of the miners have a value between 4.8 and 5.8×10^{12}/l. 23% have a erythrocytes below 4.8×10^{12}/l and 5% above 5.8×10^{12}/l. 73% of the exposed miners have normal haemoglobin within 140–170 g/l (Ref. 11), 20% – below 140 g/l and only 7% of them have a haemoglobin above 170 g/l in the blood. Reference values for MCV for erythrocytes are 83–97 fl (femtoliters or 10^{-15} l), (Ref. 11), 78% of miners have normal values, but 16% have a MCV above 97 fl and 6% have a MCV below 83 fl. Related to leukocytes, 74% of exposed miners have leucocytes between 3.3 and 9.5×10^{9}/l and 26% have leucocytes above 9.5×10^{9}/l.

We used biochemical analysis inductively coupled plasma spectrometry (ICP) as one of the most sensitive analytical techniques for the determination of elements in biological materials (serum). For hematological analyses, we used a Sysmex K-1000 Automated Hematology Analyzer, developed by Sysmex Corporation. This is an automated hematology analyzer that measures parameters such as WBC (white blood cells), RBC (red blood cells), Hgb (haemoglobin), Hct (hematocrit), MCV (mean corpuscular volume), MCH (mean corpuscular haemoglobin), MCHC (mean corpuscular haemoglobin concentration), etc.

In reality, most persons like miners were exposed to many chemicals (like heavy metals), not just one or two, and therefore the effects of a chemical mixture are extremely complex and may differ for each mixture depending on the chemical composition. This complexity is a major reason why mixtures have not been well studied. In this review we attempt to illustrate some of the principles and approaches that can be used to study effects of mixtures.

Statistical analyses were made with statistics application StatView, using descriptive statistics. Correlation *Z*-test, bivariate regression plot and graphic displays were made using a box plot, scatter and histograms.

RESULTS AND DISCUSSION

Observation of this research is the increased blood lead and zinczinc level in every one of the miners (blood lead level, mean = 0.089 mg l^{-1}; blood zinc level, mean = one, 391 mg l^{-1}) and increased blood cadmium level in 62% of exposed miners (mean = 0.007 mg l^{-1}). 48% of miners (exposed group) have an exposure period of 20 years, 29% between 10–20 years and the remaining 23% exposure period under 10 years.

The blood level rise during work experience or job exposure for lead, zinc and cadmium is shown in Figs 1–3, respectively.

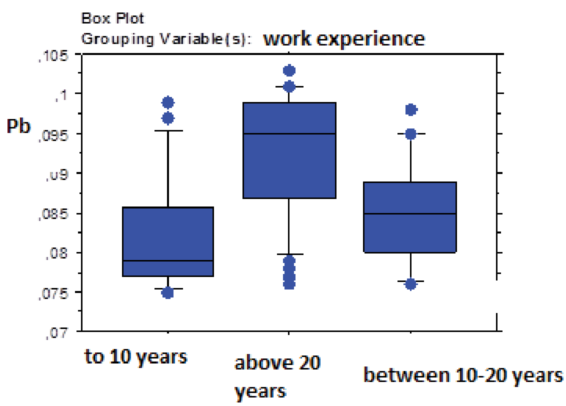

Fig. 1. Blood lead level rise during work experience

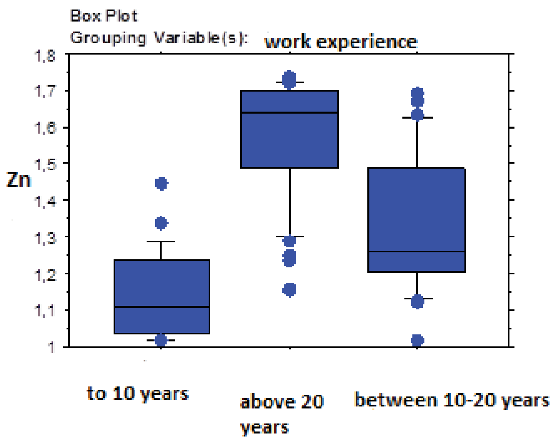

Fig. 2. Blood zinc level rise during work experience

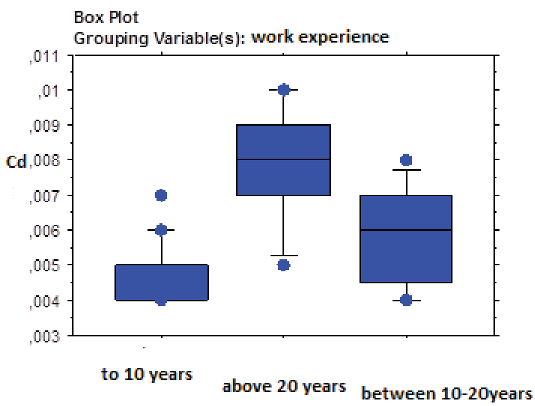

Fig. 3. Blood cadmium level rise during work experience

Ratio of number of erythrocytes with concentration of heavy metals. In the miners with lowest number of erythrocytes are evaluated the maximum lead blood level (Fig. 4).

In this research we evaluated negative correlation (r = –0.5; $p < 0.0001$) between blood lead level and number of erythrocytes (Fig. 5).

The max zinc blood levels are evaluated in the miners with lowest number of erythrocytes (Fig. 6).

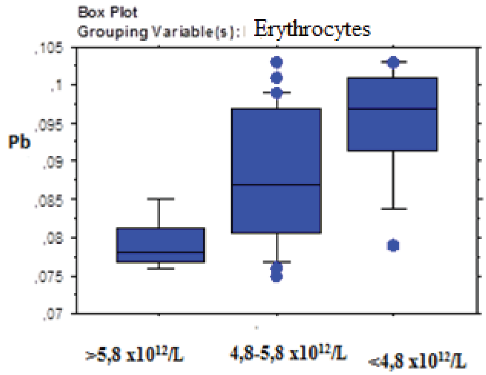

Fig. 4. Ratio between blood lead level and number of erythrocytes

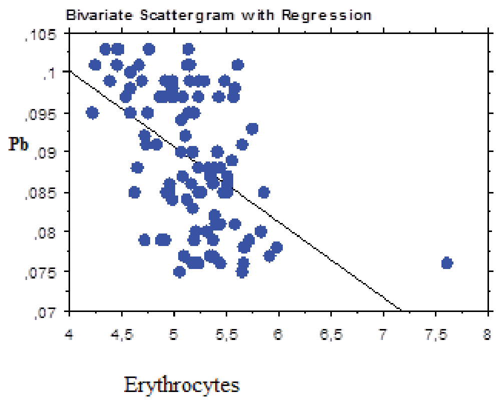

Fig. 5. Correlation between blood lead level and number of erythrocytes

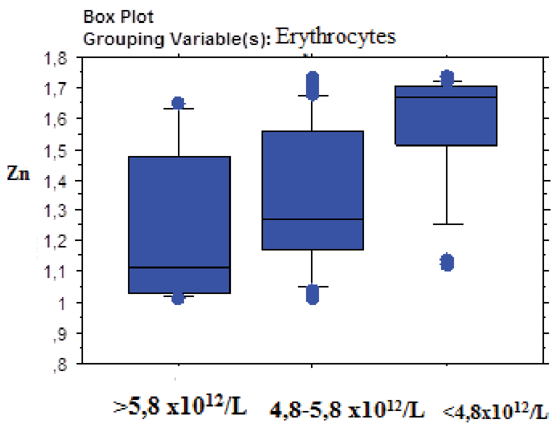

Fig. 6. Content ratio between blood zinc level and number of erythrocytes

In this research we evaluated negative correlation ($r = -0.395$; $p < 0.0001$) between zinc blood level and number of erythrocytes.

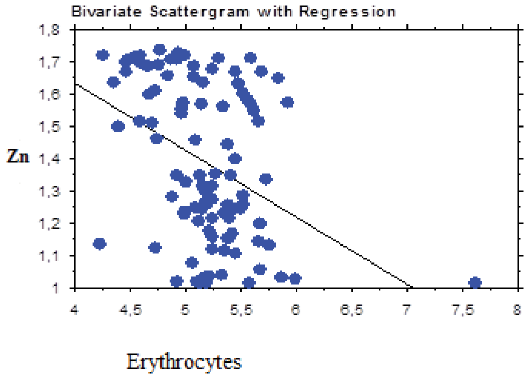

Fig. 7. Correlation between blood zinc level and number of erythrocyte

The max cadmium blood level are evaluated in the miners with lowest number of erythrocytes.

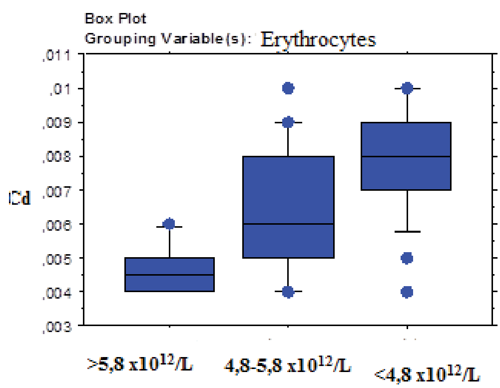

Fig. 8. Content ratio between blood cadmium level and number of erythrocytes

But we did evaluate correlation ($r = 0.002$; $p = 0.9807$) between cadmium blood level and number of erythrocytes.

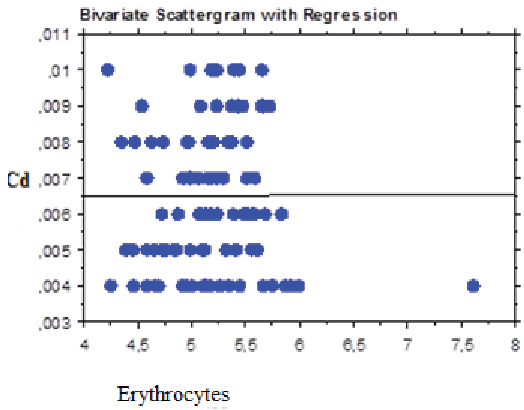

Fig. 9. Correlation between cadmium and erythrocytes

Ratio of number of leukocytes with concentration of heavy metals. In the miners with increased number of leukocytes (> 9.5×10^9/l) we also evaluated increased blood lead level (Fig. 10).

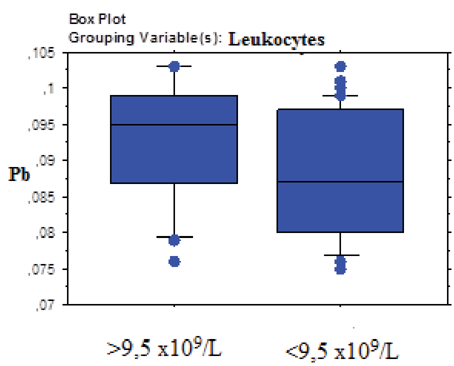

Fig. 10. Content ratio between blood lead level and number of leukocytes

Also we confirmed positive correlation between blood lead level and number of leukocytes ($r = 0.166$, $p = 0.0995$) (Fig. 11).

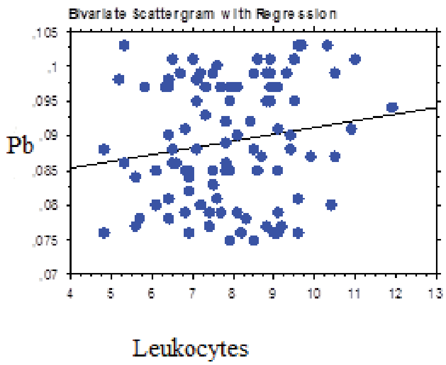

Fig. 11. Correlation between blood lead level and number of leukocytes

In miners with increased number of leukocytes (> 9.5 × 10^9/l) we also evaluated increased blood zinc level (Fig. 12).

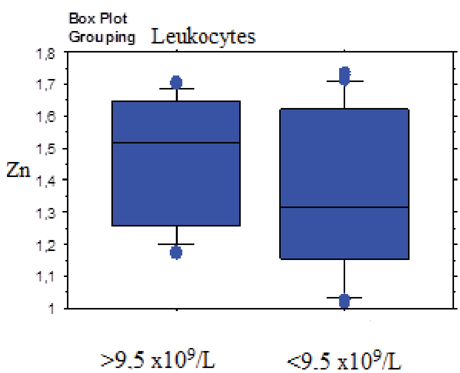

Fig. 12. Content ratio of blood zinc level and number of leukocytes

We confirmed positive correlation between blood zinc level and number of leukocytes (r = 0.124, p = 0.2187) (Fig. 13).

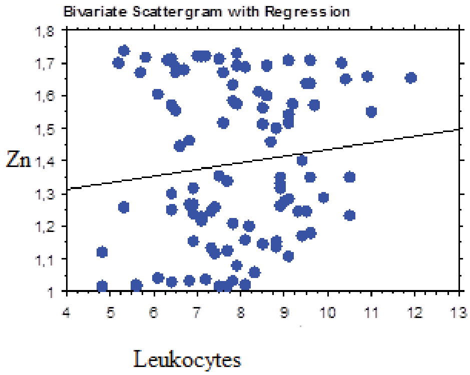

Fig. 13. Correlation between blood zinc level and number of leukocytes

In the miners with increased number of leukocytes (> 9.5 × 10^9/l) we also evaluated increased blood cadmium level (Fig. 14).

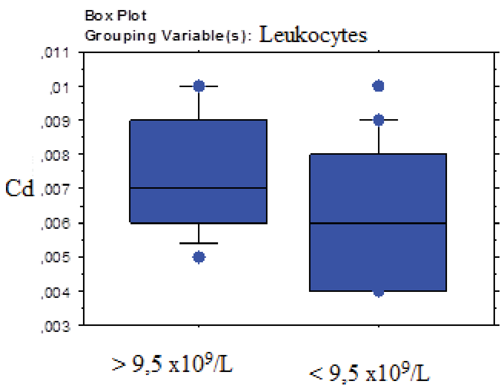

Fig. 14. Content ratio of blood cadmium level and number of leukocytes

We did not confirm correlation between blood cadmium level and number of leukocytes (r = 0.005, p = 0.9629) (Fig. 15).

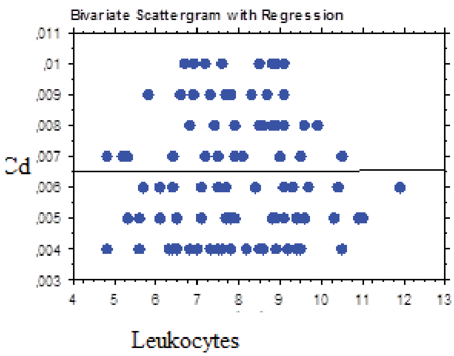

Fig. 15. Correlation between cadmium level and number of leukocytes

The results of this research confirmed that:

– blood lead, zinc and cadmium level will rise during exposure at work;

– if we now normal blood lead level as 0.04–0.07 mg l^{-1}, we concluded that all miners have high blood lead level;

– if we now normal blood zinc level as 0.1 mg l^{-1}, we concluded that all miners have high blood zinc level;– very significant negative correlation between the number of erythrocytes and blood levels of lead and zinc;

– positive correlation between the number of leukocytes and blood levels of lead and zinc;

– epidemiological survey showed that nearly all workers complained of headache;

– while 25 of 70 workers with long exposure are found to be suffering from various diseases such as asthma, respiratory tract, irritation and watering of eyes were other symptoms common to all;

– open symptoms of acute intoxication include dullness, restlessness, irritability, poor attention span, headaches, muscle tremors, abdominal cramps, kidney damage, hallucinations and memory loss;

– significant association was founded without evidence of threshold between blood lead levels and high diastolic blood pressure in people aged 21–55.

Taking into account the assessments and recommendations of the International Labour Organisation, the research determines the need for biological monitoring as a set of activities that identify and quantitatively determine the concentrations of heavy metals (lead, zinc and cadmium), their primary or secondary metabolites in biological forms such as blood in the specified category of professionally exposed workers[6,12,13]. Also we define the concept of exposure efficiency, the effective dose of toxicant, which manages a different way to enter in the body, their toxic effect (inhibition of enzymes, damage of cell membrane) and the dynamics of transport, distribution and excretion of individual metals from the body. This inconsistency may be due to differences in the concentrations of target sites on the one hand, or the capacity of the body to eliminate heavy metals (lead, zinc and cadmium). In the FYR Macedonia very little examinations concerning the impact of heavy metals such as ecotoxicological factors that cause pathophysiological changes. This research gets the meaning and enriches the fund of knowledge in this area.

Lead interferes with the activity of several of the major enzymes involved in haem biosynthesis. The only well-defined clinical symptom associated with inhibition of haem biosynthesis is anemia[6,9,10,14,15]. Leucocytosis takes about 12 h after the fever dissipates is one of the hallmarks of metal smoke fever[16]. But in the real world, people are exposed to mixtures rather than single chemicals[17]. Although various substances may have totally independent actions, in many cases two substances may act in the same location in a way that can be either additive or nonadditive. Many even more complex interactions can occur if two chemicals act in different but related goals. In extreme cases there may be synergistic effects, in which case the effects of two substances together are greater than the sum of either effect alone. In reality, most people are exposed to many chemicals, not just one or two, and thus the effects of a chemical mixture are extremely complex and may differ for each mixture depending on the chemical composition. This complexity is a major reason why mixtures are not well studied. The discussion is sublimate the overall knowledge gained through research and through her confirmation is identified hypothesis framework of the research. In addition, this inconsistency of the data is based on different concentrations of target metals in the body, on the one hand, and the ability of the organism to eliminate on the other side. In this section are analyzed and different health aspects of the respondents respectively in miners due to their occupational exposure[5,8,18–21].

CONCLUSIONS

In this research we confirmed that the miners who have been long professionally exposed to heavy metals, in the blood have increased contents of heavy metals (lead, zinc and cadmium), which have affected some haematological parameters, like erythrocytes and leukocytes, resulting in the emergence of certain diseases with complex aetiologies. The multidisciplinary elaboration of the topic suggests the need for a more serious approach to this important phenomenon (environmental impact of heavy metals in exposed workers) and is a specific model that is capable of application in other related research.

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