An anthropogenic load of copper and somatic health

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Abstract. The issues of good health and well-being for people have been reflected in the UN Sustainable Development Goal No. 3. The presented paper focuses on the increase in the copper content in the body by 3-4 times within 3-4 months. It is established that such an increase is not accompanied by a change in the biochemical parameters of blood and the structure of somatic pathology characteristic of the population of Tomsk, who are not engaged in industrial production.

1. Introduction
An analysis of a person’s hair and nails is considered the most appropriate way for a mass non-invasive assessment of the elemental status and homeostatic capacity of metals [1]. According to A.V. Bgatova et al. [2], any disease can be seen as a consequence of a violation of the internal environment (homeostasis) of the body. At the same time, the official boundaries of the “norm” on the content of chemical elements in the hair of people are not established [3], particularly due to their dependence on the region of human residence [4]. Due to the large scatter of values, the poorly regulated definitions of “recommended levels” and “biologically acceptable levels” [3-5] are proposed. In workers of industrial enterprises, the amount of metals in the body can be increased by 20-50 times according to the methodical recommendation of the USSR Ministry of Health for professional activities (1988). However, there is no data at which excess of the optimal content in the body vital elements become toxic. Dismikroelementozes are distributed in the Russian Federation as a whole and in the Siberian region in particular, having an impact on a low level of population health [1].

The paper presents the results of the analysis of the content of zinc and copper in workers of the industrial enterprise of Tomsk. These elements in certain quantities belong to the biotic group, in the absence of anthropogenic human exposure. Potential linkages of essential (vital) metals with known markers of natural aging of the population have been studied.

2. Materials and Methods
Examination of employees was carried out as part of a preventive medical examination. The examination of healthy volunteers was carried out with the permission of the Ethics Committee (conclusion No. 583 of March 19, 2007) of the Siberian State Medical University (Tomsk). The subjects were informed on the features of the conducted diagnostic procedures in accordance with ethical requirements of the men and women employed in the production of Methanol OJSC (Tomsk, Russia). The hair was cut off at 3-5 points with a thickness of 2-3 mm². The total volume of the sample was about 100 mg. Quantitative chemical analysis of hair samples for zinc and copper content is based on a stripping voltammetric
method for determining the mass concentrations of elements in a prepared sample solution [6]. Blood biochemical indices (concentration of glucose, cholesterol, lipoproteins of low (LDL) and high (HDL) density) were detected by standard methods according to the instructions. Semi-quantitative assessment of the state of parenchymal organs was carried out in points according to ultrasound investigation (USI). The absence of structural changes in the parenchyma was taken as 1 point. In the case of detected organic changes in each organ (liver, gallbladder, kidney, pancreas, thyroid, and prostate), an additional score was added.

The results were expressed as mean (X) and standard deviation (SD), median (Me), 1st (Q1) and 3rd (Q3) percentiles. The statistical processing of the results was carried out by the methods of variation statistics using the Mann-Whitney criterion and the Spearman rank correlation coefficient.

3. Results

Analysis of the type of distribution (universal criteria of Lilliefors and Shapiro-Wilk) of the quantitative contents of zinc and copper in the hair of men and in women showed that the results obtained for zinc can be considered close to the normal distribution (Fig. 1a, b).

![Figure 1. Histogram of zinc distribution in hair: (a) in women; (b) in men.](image)

When studying the distribution of copper in the hair, a deviation from the normal distribution was noted. The type of distribution obtained indicates a strong impact of external sources of metal in the body (Fig. 2a, b). Considering the types of distribution, the values of elemental load in the hair of the employees of the enterprise were described, both as an average value ($\pm$SD) and as values of centile concentration intervals.

A professional examination of the company’s employees (Table 1, 2) showed a statistically significant 3-4-fold excess of the regional indicator for copper concentration in the hair of both men and women. Sexual differences in the accumulation of copper were not detected (Table 1). Therefore, the groups were combined for comparison with the corresponding indicator for the population not engaged in the production of methanol. In the blood, the concentration of cholesterol and its low density fraction (LDL) exceeded the recommended level (Table 2). According to ultrasound data, only 11% of the surveyed employees of the enterprise, mostly young and middle-aged, do not have structural changes in the internal organs.
biochemical parameters were found in the blood of men, with all the blood parameters studied except for HDL; also in women (r=0.27; p<0.04; n=61-62), except for HDL and glucose levels. At the same time, no significant correlations of Zn and Cu content in the hair and blood biochemical parameters were found in the employees of the enterprise (men and women).

The predominance of diseases of the excretory systems of the body (biliary excretion, urination) suggests a chronic intake of copper in the body.

Table 1. The level of trace elements in the hair of the surveyed, X±SD, Me(Q1-Q3).

| Group | Age (years) | Zinc (mg / kg) | Copper (mg / kg) |
|-------|-------------|----------------|------------------|
| Recommended levels for men and women [1, 2, 4, 5] | - | 140-280 | 6.5-15 |
| Male workers, N=180 | 43.7±11.4 | 132.6±53.3 | 38.70±29.52 |
| Female workers, N=64 | 42.0±8.5 | 118.8±47.8 | 31.95±25.04 |
| Employees of the enterprise (men and women), N=244 | 43.3±10.8 | 129.3±52.2 | 29.35(19.10-48.90) |
| Men and women who did not work in the enterprise, N=58 | 30.6±12.4 | 113.2±52.9 | 10.26±10.17 |

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Table 2. Biochemical blood parameters (mM) in different categories of patients, X±SD.

| Group | Glucose | Cholesterol | LDL | HDL | LDL / HDL | Pathology of organs points |
|-------|---------|-------------|------|------|-----------|---------------------------|
| Recommended levels [7] | 3.5-6.1 | < 5.0 | < 3.0 | >1-1.2 | < 3.0 | 1.0 |
| Male workers | 5.06±1.06 | 5.92±1.05 | 3.75±0.92 | 1.34±0.27 | 2.93±0.91 | 2.64±1.05* |
| Female workers | 4.92±0.89 | 5.96±1.02 | 3.64±0.86 | 1.62±0.39 | 2.43±1.02 | 3.27±1.28* |

Correlation analysis allowed us to establish a direct link between the age of the company’s employees and biochemical markers of aging: in men, with all the blood parameters studied (r=0.17-0.44; p<0.03; n=168-171), except for HDL; also in women (r=0.27-0.42; p=0.04; n=61-62), except for HDL and glucose levels. At the same time, no significant correlations of Zn and Cu content in the hair and blood biochemical parameters were found in the employees of the enterprise (men and women).
4. Discussion
Excess copper in the body can be associated with an increase in its release from the environment or with reduced excretion. An elevated level of the trace element testifies, first of all, in favor of the pathology of the liver (hepatitis, the risk of cirrhosis) and kidneys [5]. However, organ pathology among employees of the enterprise as a whole did not differ from that among the population of the Tomsk region of comparable age. Therefore, the main reason was the occupational hazard associated with the constant use of a copper catalyst in the methanol production process. The direct correlation of copper-zinc (r = 0.26; p <0.001; n = 244) in the group of surveyed employees of the enterprise indicates a chronic supply of copper from the external environment. Although, these metals in normal conditions (state of rest) are the competitors [4].

It should be emphasized that the relatively healthy volunteers of the city of Tomsk, who participated in the survey, also do not have a correlation of copper and zinc concentrations in the hair with age. An increase in the level of cholesterol and its fractions in the blood is a well-known marker of the natural aging processes.

5. Conclusion
Thus, a 3-4-fold increase in the copper content in the body of workers of an industrial enterprise for at least 3-4 months is not accompanied by changes in the biochemical blood parameters and the structure of somatic pathology characteristic of the population of the region.

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