



## Abstracts

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Peoples' Friendship University of Russia (RUDN University), Moscow, Russia

### Abnormally low selenium status of domestic animals and humans in conditions of extremely high groundwater pollution with Se, Li, F, NO<sub>3</sub>, B, Cd, and As

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Se content in drinking water rarely exceeds maximum permissible concentration level (MPCL, 10 µg/L) but chronic consumption of water with toxic Se levels is known to increase morbidity of several forms of cancer and neurodegenerative diseases. Nevertheless, MPCL levels are adopted for individual pollutants not taking into consideration the possibility of the effect of other toxic elements. In the southern province of Mongolia (Dorno-Govi), using ICP-MS and fluorimetric analysis of Se we have revealed for the first time abnormally low Se status of domestic animals and humans in conditions of extremely high groundwater concentration of Se, Li, F, NO<sub>3</sub>, B, Cl, Cd, and elevated levels of As, being indicative of antagonistic relationships between Se and other contaminants. In these respect multielement analysis of human hair may become the most prospect indicator of environmental risks.

### Effect of a standardized bischofite solution on the reproductive function of male rats with experimental hypomagnesaemia

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**Objective:** To study the effect of standardized bischofite solution (SBS) on the spermatogenesis in male rats with dietary magnesium deficiency (DMD). **Materials and methods:** Experiments were carried out on 90 male rats in 3 equal groups (1: intact control, 2: low magnesium, 3: low magnesium with SBS treatment). For modeling the DMD, rats of the groups 2 and 3 were kept on a diet without magnesium AIN-76 for 2 months. Then, the rats of group 3 were treated by SBS 0.01 mL/kg for 2 months, while groups 2 and 3 continued to receive a low-magnesium diet. Reproductive function of males with DMD, and after its correction with SBS, was evaluated at the end of the 2 and 4 months. **Results and discussion:** After 4 months in group 2 total spermatozoa (TS) was decreased by 48%, time of motility of spermatozoa (TMS) by 45% and spermatogenesis index (SI) by 11.9%, whereas the number of pathological forms increased by 81.8% compared to controls. In group 3 TS, TMS, and SI were increased 3.5-fold, 2-fold, and 12.8%, respectively. **Conclusion:** SBS promotes activation of spermatogenesis in male rats with

dietary hypomagnesaemia, being indicative of its potential effectiveness for correction of DMD.

### Assessment of cobalt and iron content in immature mice following chronic CoCl<sub>2</sub> exposure

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The aim of the study was to assess the iron distribution in blood serum, erythrocytes (RBC), spleen, and liver in relation to Co accumulation in immature mice. Pregnant ICR mice were subjected to 125 mg/kg b.w. daily CoCl<sub>2</sub> × 6H<sub>2</sub>O for 2 – 3 days before birth and during lactation. 25-day-old offspring were separated into individual cages and had free access to food and water. Tissue metal levels were assessed using inductively-coupled plasma mass-spectrometry. Chronic CoCl<sub>2</sub> exposure induced significant metal accumulation in RBC and blood plasma compared to the control values (tap water). Spleen and liver Co content in the exposed mice increased ~ 5-fold and 20-fold, respectively. Co concentration was

significantly higher in plasma and liver of day-30 mice, compared to day-25 mice. Fe content was also ~ 3-fold increased in samples of Co-exposed mice, suggesting a strong relationship between Co exposure and Fe metabolism. The study was supported by Grant No DMU 03/25 from the Bulgarian National Science Fund and the Russian Foundation for Basic Research (No. 18-54-18006).

### Significance of trace elements in children with bronchial asthma of Amur region

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This study involved a total of 314 children including 155 children with bronchial asthma (BA) and 189 non-asthmatic children of the control group. Element contents were measured by means of atomic absorption spectrometry (Hitachi-Z9000, Japan). In spite of the same geochemical region of residence, BA patients were found to have significantly lower serum levels ( $\mu\text{mol/L}$ ) of copper (10.7 vs. 6.4), selenium (2.0 vs. 1.3), and zinc (39.3 vs. 34.1) and higher levels of lead, nickel (0.2 vs. 0.001), and cobalt (0.9 vs. 1.2). Decreased selenium (1.0 vs. 0.7) and copper (6.7 vs. 4.9) levels and increased lead (0.001 vs. 0.1), manganese (1.3 vs. 2.0), and lithium (1.4 vs. 1.8) levels were found to be associated with the increase in the BA severity. The *in vitro* effect of metals (lead, selenium) salts on RBC membrane transformation in asthmatic patients significantly depends on BA severity ( $R = 0.75$ ,  $R = -0.79$ ). The data obtained open the way for personalized prediction, diagnosis, and correction of trace element imbalance in BA patients.

### Gender differences in the content of trace elements in primary teeth

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Primary teeth were examined for the content of trace elements (iron, lead, selenium) and macroelement (sodium and potassium) in 27 boys and 23 girls aged 4–5 years living in Moscow. The content of the studied elements in the enamel of the gender groups did not differ significantly. At the same time, the relationship between the body weight of the examinees and primary teeth iron content varied significantly: in boys, the coefficients of regression were 0.372 ( $p < 0.05$ ), whereas in girls they were  $-0.165$  ( $p < 0.05$ ). The dependence of selenium content on body weight was also gender-specific, being characterized by correlation coefficients of 0.24 and 0.63 ( $p < 0.05$ ) in boys and girls, respectively. In turn, correlation between the content of Na and K was significant in boys ( $r = 0.38$ ;  $p < 0.05$ ), but not in girls ( $r = 0.08$ ;  $p > 0.05$ ). Hypothetically, hormonal differences may predetermine the binding of trace elements to the tooth enamel, depending on the vegetative balance of the organism.

### Age-related changes in hair toxic metal levels in children with chronic sinusitis

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The aim of the study was to investigate the levels of toxic metals in hair of children with chronic sinusitis and age- and gender-matched controls. Hair metal levels ( $n = 150/150$ ) were assessed using inductively-coupled plasma mass spectrometry after mi-

crowave digestion of the samples. Hair levels of As (24%) and Be (2-fold) were significantly higher in the sinusitis group as compared to the controls. The difference was also age-specific. Particularly, in the group of younger children ( $< 10$  years old) only As and Be levels exceeded the control values, whereas in the elder group ( $> 10$  years old) a significant increase of hair Hg was also observed in parallel with elevated As and Be levels. Generally, the obtained data are in agreement with the earlier studies indicating the potential toxic role of arsenic and beryllium in respiratory epithelia. Hypothetically, chronic sinusitis is altered metal handling from the ambient particles with impaired metal particle removal from the upper airways and their subsequent toxicity.

### Bone and bone regenerate trace element content under high-altitude conditions

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The aim of the work was to investigate trace element redistribution in bone tissue during transosseous distraction osteosynthesis. A total of 72 outbred dogs (control, osteosynthesis under high- and low-altitude conditions) were involved in the study. Bone trace element content was assessed by atomic absorption spectroscopy. At the end of the experiment, a nearly 75% decrease in bone Mg levels was observed in the high-altitude animals group. Bone Sr levels were under the limit of detection for the low-mountain group, whereas at day 20 significant Sr levels were observed in the high-altitude group. The Cu and Pb content in the bone regenerate of both experimental groups was significantly lower as compared to the control group. No significant group difference of in Fe

content was observed in any the experimental groups. Dynamic changes of trace element content were also observed during the regeneration of bone tissue in high-altitude conditions, being characterized by a decrease of Ca, Mg, Fe, Co, Al level and an increase of Ti, Mo, Zr, and Si levels. The changes in trace element composition of the distraction regenerate provide a background for the false joint formation.

### Trace element status of children with Down's syndrome

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The objective of the study was to assess gender specificity of hair essential and toxic element content in children with Down's syndrome using inductively-coupled plasma mass-spectrometry. Male and female hair phosphorus levels in Down's syndrome patients significantly ( $p < 0.001$ ) exceeded the control values by 36% and 30%, respectively. Hair Zn in male and female Down's syndrome patients was 54% and 109% higher than the control values. Boys with Down's syndrome were characterized by elevated hair Mg content, whereas girls had higher hair Cr and Si levels. Notably, hair Hg levels were found to be significantly reduced both in girls and boys, whereas hair content of Pb (boys) and As (girls) was elevated. Gender-syndrome interaction was found to be significant only in the case of Cr and Hg. Hypothetically, altered trace element and mineral status in patients with Down's syndrome may at least partially contribute to aggravation of DS-associated neurological dysfunction as well as metabolic disturbances including obesity and osteoporosis. The investigation is supported by the Russian Foundation for Basic Research within project No. 18-013-01026.

### Trace element composition of blood during pregnancy complicated by intoxication with lead acetate and sorption correction

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The aim of research was to study the level of trace elements in blood during pregnancy complicated by lead intoxication under correction with enterosorbent – nanocarbon mineral sorbent (NUMS). The study was conducted on 40 female Wistar rats according to the ethic guidelines. Blood was taken under anesthesia on the 21<sup>st</sup> day of the pregnancy. Intoxication was induced before pregnancy by administering of 20 mg/kg of lead acetate solution for 18 days. Sorbent NUMS was administered enterally for 14 days and for several experimental groups: 1: control, 2: pregnant, 3: pregnant with intoxication, 4: pregnant with intoxication and injection of NUMS. The analysis of blood serum was performed for 11 elements by atomic emission spectrometry (iCAP 6000 Intertech Corp., USA). Lead intoxication during pregnancy led to an increase of its content in the blood by 16%, whereas the content of other elements except copper decreased significantly. During the intoxication and sorbent administration in pregnancy lead content decreased by 40% compared with group 3, the content of the other elements decreased as compared with group 2. Lead intoxication during pregnancy disrupts the balance of trace elements in the maternal organism and results in lead accumulation, whereas enterosorbent treatment helps to reduce the lead content without affecting essential trace elements.

### Hair zinc levels in children with frequent acute respiratory infections

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The objective of the study was to assess hair Zn levels in “frequently ill children”, a group of children being characterized by 4 – 6 episodes of acute respiratory infections a year. Hair Zn levels of 400 “frequently ill children” with otolaryngeal disorders and 100 healthy controls aged 1 – 9 years living in St. Petersburg (Russia) were assessed using inductively-coupled plasma mass spectrometry. Hair Zn levels in the patients was 32% lower as compared to the controls (113 (65 – 166) vs. 166 (113 – 214)  $\mu\text{g/g}$ ,  $p < 0.001$ ). Further stratification by disease according to ICD-10 (J31, J32, J35, J37) also demonstrated significant group difference in relation to the control values. Children with chronic pharyngitis, laryngotracheitis, and chronic diseases of tonsils and adenoids but not with chronic sinusitis were characterized by significantly lower hair Zn levels. The lowest levels being 2-fold lower than the control values were observed in children with chronic laryngotracheitis. The obtained data are in agreement with the role of Zn in modulation of immune response. Correction of Zn deficiency in “frequently ill children” may improve the frequency of respiratory infections.

### Hair and serum trace elements in autism spectrum disorders in relation to clinical severity

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The objective was to study the association between metabolic trace element status and clinical characteristics in 76 children with autism spectrum disorders. Hair (H) and serum (S) trace element levels were assessed using inductively-coupled plasma mass spectrometry at NexION 300D (PerkinElmer Inc., USA). Multiple regression analysis allowed to reveal a significant ( $p < 0.05$ ) relationship between the presence of psychopath-like syndrome and S-Fe ( $\beta = -0.393$ ) and H-Fe ( $\beta = -0.320$ ), speech development delay and H-Cu ( $\beta = 0.281$ ) and S-Co ( $\beta = 0.391$ ), infantile psychosis and H-Zn ( $\beta = -0.332$ ). 33% ( $p = 0.005$ ), 17% ( $p = 0.089$ ), and 31% ( $p = 0.007$ ) of the variability of these characteristics were responsible for the overall models. Hypothetically, alteration of metal ligand homeostasis may be associated not only with the presence of autism spectrum disorders but also with the development of particular clinical syndromes. The investigation is supported by the Russian Foundation for Basic Research within project No. 18-315-00103.

### The metal content in soils and in the hair of population of center of mining industry

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The study was conducted in the vicinity of the active mining indus-

tries on the territory of the Sibay city of Republic Bashkortostan. The main aim was to concurrently determine the concentrations of metals in the hair of adult (12 men, 26 women) and in the soil (10 sites). For the determination of the total concentration of soil metals an inductively coupled plasma mass spectrometry (ICP-MS, Contr AA, Analytik Jena) was used. The hair samples were subjected to multi-element analysis using a combination of ISP-AES (Optima 2000DV, PerkinElmer Corp.) and ICP-MS (ELAN 9000, Perkin Elmer Corp.). Preparation of samples for analysis was carried out using microwave decomposition (Multiwave 3000, A. Paar). The results showed that soils from Sibay contained an increased level of Cu, Zn, and Cd. The concentrations of Zn in the hair were significantly above the average level of the metal in hair documented for Russia. At the same time, deficiency of Fe and Co was revealed. Thus, our results show that the natural and technogenic characteristics of the mining territory predispose to the occurrence of trace element imbalance in population.

### Regional assessment of the impact of diet on mercury levels in the pediatric population

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Aim of the study was to assess the relationship between the dietary intake and the content of mercury (Hg) in children's hair samples. We investigated Hg in the hair of 180 children aged 3 – 7 years old from the city of Kazan by means of ICP-AES and ICP-MS at ANO "Center for Biotic Medicine" (Moscow). At the same time, we assessed the intake of Hg with the diet of children from the children's institutions according to menu production of 14 days. The findings were supplemented with the parents' questionnaire. The frequency of fish intake was found to be 1 – 2 times a week, corresponding to  $0.37 \mu\text{g} \times \text{kg}^{-1} \times \text{day}^{-1}$  of Hg. The

major contribution to Hg exposure at the level of the 95<sup>th</sup> percentile was made by meat products (28.8%), cereals and bakery (42.7 %), and fish (19.8%). The total intake of Hg with all foods was found to be  $1.3 \mu\text{g}/\text{kg}/\text{day}$ . The 95<sup>th</sup> percentile of Hg distribution in children's hair was observed as  $0.313 \mu\text{g}/\text{g}$ , being considerably lower than the limit recommended by US-EPA ( $1 \mu\text{g}/\text{g}$  of hair) and WHO ( $1.9 \mu\text{g}/\text{g}$  of hair) for the vulnerable population group. Our studies showed insignificant impact of Hg associated with intake of fish and other food groups. This work was funded by the subsidy allocated to Kazan Federal University for the state assignment in the sphere of scientific activities 19.9777.2017/8.9

### Trace element status in pregnant women of the Amur region

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A comprehensive clinical and laboratory research of 408 women was carried out during and after their pregnancy. The environment in the Amur region is characterized by low level of I, Se, high content of Mn, Fe, Zn, and an imbalance of other trace elements. Thus, four groups were formed including: non-pregnant women, pregnant women with normal amount of Hb or control group, with reduced amount of Hb and without Fe deficiency, pregnant women with reduced amount of Hb and Fe deficiency. Trace element status was estimated using atomic-absorption analysis. Data demonstrated increased Cu levels in serum and its decreased content in blood cells. In anemia, regardless of the level of Fe, there was a decrease in Co and Se in serum and an increase in Mn in blood cells. The distinct features of trace element status were observed for iron deficiency anemia (increased serum

Mn) and for iron-saturated anemia (increased serum Li and increased blood cell Li and Co content). These changes in anemic state can be attributed to polymicroelementosis and justify the correction of alterations.

### Seasonal changes of plasma trace elements in women of different ethnic groups

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The aim was to study the seasonal changes of blood plasma trace element concentrations in women of different ethnic groups living in the Caucasian Mineral Waters region. 345 practically healthy women (195 Russian and 150 Greek) aged 20 – 30 years were examined in different seasons of the year. Analysis of trace element concentrations in blood plasma was performed using ICP-AES and ICP-MS methods. It was found that the maximum concentration of Se and Zn was observed in winter, Cr in spring, Cu in summer regardless of ethnicity, and Fe and Mn in Russians in autumn and in Greek in summer. Mean annual concentrations of Fe, Cu, and Mn were significantly higher in Greek women, whereas Se, Zn, and Cr levels were higher in Russians ( $p < 0.05$ ). Spearman's correlation analysis showed a direct correlation between mean annual concentrations of Cu and Mn in Russian ( $r = 0.69$ ,  $p < 0.01$ ) and in Greek women ( $r = 0.73$ ,  $p < 0.01$ ). Thus, the obtained results indicate that plasma trace element levels and the quality of life assessment in women of different ethnic groups in the Caucasian Mineral Water region are subjected to seasonal biorhythms. Data on these patterns allow to correct metabolic rate and supplement the organism with necessary micronutrients according to seasonal variations.

### Selenium exposure affects essential element content in cereals

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The purpose of this study was to determine the content of essential elements (Cu, Fe, Mn, and Zn) in cereals (wheat, mustard, rice, maize) growing in areas with high Se content (Punjab, India) using inductively coupled plasma mass spectrometry. Various cereals responded differentially to Se exposure. In particular, Se-rich mustard accumulated significantly higher levels of all studied elements (Cu, Fe, I, Mn, Zn). In contrast, Se-rich maize was characterized by significantly decreased levels of the majority of the studied elements (Cu, Fe, Mn, Zn) except I, being 80% higher as compared to N-Se maize. In turn, Cu and Mn content was significantly higher in H-Se wheat, whereas Fe levels were reduced as compared to the baseline. In H-Se rice only Mn content exceeded the control values, whereas other elements studied were characterized by a decrease or absence of significant group difference. The study is supported by the Russian Foundation for Basic Research No. 17-55-45027) and Department of Science and Technology, Government of India (INT/RUS/RFBR/P-252)

### Laser spectrometry of living beings as a system of non-invasive rapid control methods, early diagnosis, remote monitoring, and legal assessment of human element status and environmental safety

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The control of bioelement status of living beings in general is the main approach for the assessment of imbalance in content of organic and inorganic bioelements. Laser spectrometry not damaging living organisms – laser breakdown (LIBS), Raman and fluorescence spectrometry (LIF) – has received a new expand with the development of mobile laser sources and portable wide-range spectrometers, new methods of quantitative analysis using virtual standards “Gravistan”. The most promising areas: laser emission analysis of nails, Raman spectrometry of nails for early diagnosis of osteochondrosis and osteoporosis, diagnostics of malignant melanoma. The final assessment must be performed by a court within the framework of a forensic-environmental examination. In any case, an integrated approach to monitoring the content of bioelements in living beings and environment using mobile spectral instruments may be important to control the health and safety.

**Daily variability of salivary trace elements in women with uterine myoma**

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The aim was to study the circadian variability of trace elements in whole saliva in reproductive age women with uterine myoma and healthy controls. 68 women with uterine myoma and 46 practically healthy controls in the follicular phase on day 6 – 8 of the menstrual cycle aged 20 – 42 years were examined. Analytical determination of the content of trace elements in whole saliva was carried out using ICP-AES and ICP-MS methods. It has been demonstrated that women with uterine myoma were characterized by a significant decrease in the concentration of Cu and Zn in saliva in comparison with healthy ones ( $p < 0.001$ ), especially in the evening, hypothetically being indicative of a decrease in antioxidant system activity during this time of day. The Spearman correlation analysis showed a direct correlation between the Zn and Cu concentrations in the morning ( $r = 0.61$ ,  $p < 0.05$ ) and in the evening ( $r = 0.49$ ,  $p < 0.05$ ). Therefore, the revealed that changes in the chronostructure of the circadian dynamics of trace element excretion in women with uterine myoma may be indicative of the phenomenon of internal desynchronization.