territories of the Arctic zone of the Russian Federation». (in Russ.).]

8. Поливанова Т.В. Вопросы адаптации и патологии у населения Крайнего Севера. *Якутский медицинский журнал.* 2011; 35(3):67-71. [Polivanova T.V. Questions of adaptation and pathology in the population of the Far North. *Yakut medical journal.* 2011; 35(3):67-71. (in Russ.).]

9. Чащин В.П., Гудков А.Б., Чащин М.В., Попова О.Н. Предиктивная оценка индивидуальной восприимчивости организма человека к опасному воздействию холода. *Экология человека.* 2017; 5:3-13.[Chashchin V.P., Gudkov A.B., Chashchin M.V., Popova O.N. Predictive assessment of individual human susceptibility to damaging cold exposure. *Human Ecology.* 2017; 5:3-13.]

10. Шишкин Г.С., Устюжанинова Н.В. Функциональные состояния внешнего дыхания здорового человека. Новосибирск: Изд-во СО РАН. 2012:329. [Shishkin G.S., Ustjuzhaninova N.V. Functional status of the external breathing in healthy person. Novosibirsk. 2012: 329. (in Russ.).]

11. Fitzgerald R.S. Oxygen and carotid body chemotransduction: the cholinergetic hypothesis – a brief history and new evaluation. *Respirat.Physiol.* 2000; 5 (120): 89-104.

12. van Ooijen A.M., van Marken Lichtenbalt W.D., van Steenhoven A.A. [et al.] Seasonal changes in metabolic and temperature responses to cold air in humans. *Physiol.Behav.* 2004; 2-3 (82): 545-553.

13. Weibel E.R. Gas exchange: large surface and thin barrier determine pulmonary diffusing capacity. *Minerva Anestesiol.* 1999; 6 (65):377-382.

14. West J.B. Respiratory physiology - the Essentialis. Baltimore: Lippincott, Wilcins, 2008: 180.

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MICROELEMENTAL COMPOSITION OF BLOOD AMONG ABORIGINAL INHABITANTS OF THE ARCTIC

ABSTRACT

The level of microelement status indicators in the blood of aboriginal inhabitants of the Arctic is determined, on the basis of which it is possible to conduct future comparisons under conditions of industrial development of territories. The study included 107 indigenous inhabitants of the North, belonging to the ethnic group of Dolgan, living in Yuryung-Khaya of the Anabar district of Yakutia. The content of 20 microelements in the blood serum was studied.

The content of many elements, including manganese, cobalt, strontium, nickel and iron in blood is higher than reference values, which can influence the development of diseases of the cardiovascular system, nephropathy and oncological diseases.

Keywords: trace elements, indigenous peoples of the North, Arctic.

Introduction. The stability of the chemical composition of the body is one of the most important and necessary conditions for its normal functioning. Accordingly, deviations in the content of chemical elements caused by environmental, occupational, climatogeographic factors or diseases lead to a violation in the state of health [6]. The Northern territories are extremely different from the Central regions of Russia by climatic, biogeochemical, dietary and adaptive characteristics.

Alluvial diamond deposits are being developed in the valley of River Ebelyah, which is the left tributary of the Anabar River in Yakutia. During the development of the natural landscape structure and environmental conditions have undergone significant changes. A special danger in the development of the Deposit is the contamination of the surface layer of soil with chemical elements with toxic and radioactive properties contained in the ore. Filtration effluents of the downstream of the wellhead dam of the concentrator form a clear technogenic hydrochemical anomaly of manganese, chromium, Nickel, copper, lead and molybdenum [4, 9].

Toxic elements, migrating to streams and rivers in the form of mineral particles, accumulate in the bottom sediments and gradually decomposing, for a long time, fall into large watercourses, on the banks of which are located settlements. The local population drinks this water, uses it for economic purposes, eats fish that lives in this water and feeds on microorganisms that inhabit these watercourses, thereby accumulating toxic elements in their bodies. The danger of area pollution of the environment with toxic radioactive elements and heavy metals is associated with wind drift of mineral particles from the quarry and from the dumps of off-balance ores [4, 9]. Area dispersion of mineral particles with toxic elements accumulates in plants, primarily in the moss, where it enters the body of animals and birds. When consumed in food, a person also accumulates toxic elements in his body. Poisoning of the body as a result of these factors, the process is hidden and "stretched" in time, depends on the individual characteristics of the human body

and lifestyle, eating behavior, as a result, it is impossible to accurately determine the cause of a disease.

In this regard, we conducted this study in order to establish a regional baseline indicators of the elemental status of the body of indigenous inhabitants of the Arctic, on the basis of which future research will be conducted.

Materials and methods of research. In the present study involved 107 native peoples of the North, on a nationality the Dolgans. The surveyed population lives in isolation in the tundra on the bank of the Anabar River, the village of Yuryung-Khaya. It is Anabar district of the Republic of Sakha (Yakutia). Prior to inclusion in the study, written informed consent was obtained from residents. The survey was conducted in accordance with the principles and ethical standards established by the Helsinki Declaration.

Blood sampling from the ulnar vein is done in the morning on an empty stomach using a test tube "Vacutest". The obtained blood was centrifuged with the aim of obtaining serum for 10 minutes at 1800 R/min. Serum was separated and frozen ependorf at a temperature of -27°C for storage and transport. By atomic emission and mass spectrometry with ionization in inductively coupled argon plasma on the instrument the mass spectrometer ICP-MS Elan 9000 (Canada) we examined the serum of blood of the next 20 microelements: phosphorus (P), scandium (Sc), titanium (Ti), vanadium (V), chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co), Nickel (Ni), copper (Cu), zinc (Zn), arsenic (As), rubidium (Rb), strontium (Sr), yttrium (Y), niobium (Nb), cadmium (Cd), cesium (Cs), thallium (Tl), lead (Pb). The content of the studied chemical elements in blood serum was expressed in micrograms per liter (μg/l).

Statistical processing of the obtained results was carried out with the help of SPSS 19 application software package. A descriptive analysis of the numerical characteristics of the signs (Me (Q25-Q75) median (interquartile range 25 and 75). At comparing the differences in the groups, nonparametric evaluation criteria (Mann-Whitney U – test) were used. Statistically, the significance of the differences was considered significant at $p< 0.05$.

The results and discussion. In the study were men 35 (32.7 %) and women – 72 (67.3 %). The age of the subjects was from 20 to 77 years. The average age of men was 51 (42-60) years, women – 45.5 (34-54) years, without statistically significant differences (p=0.094). Median concentrations were calculated to determine the content of trace elements in blood serum.

The contents of one of the main "structural" elements of the person, and phosphorus (P), most Dolgan high 148,02 (124,01-171,60) mg/l, more than 3-4 times the data of residents of other regions of Russia (25,08-44,91 mg/l) [2, 3], which is probably due to traditional fish food. Phosphorus plays a fundamental role in many basic cellular processes, such as bioenergy, intracellular signaling and mineralization of bones and teeth, it is a part of nucleic acids, cell membranes [1].

According to our data, the content of scandium (Sc), chromium (Cr), lead (Pb) in the blood corresponded to the data of literary sources.

Chromium (Cr) – is important for the normal course of carbohydrate metabolism in the human body. The main role of chromium is to reduce blood glucose levels.

The need for chromium increases in people as a result of various stresses, fatigue, injuries, diabetes and diseases of the cardiovascular system [6].

The content of copper (Cu), zinc (Zn), rubidium (Rb) was above the upper limit of reference values (Table 1).

Copper (Cu) – one of the essential elements necessary for the normal functioning and development of the body. The source of copper is food. Being a part of 16 different metalloproteins, copper is an essential element for the cells of the body. It is also important in iron metabolism. Copper is rapidly absorbed from the stomach and upper intestine, deposited in the liver and in various copper-containing cell proteins in plasma [11].

Biological functions of zinc (Zn) are determined by the fact that it is part of metalloenzymes, RNA and DNA polymerases, carboxypeptidase and alcohol-dehydrogenase. Zinc absorption occurs mainly in the duodenum and proximal intestine. Especially rich in zinc, prostate, semen, liver, kidney, retina, bone and muscle. The concentration of zinc in red blood cells is 10 times higher th Rubidium (Rb) - little-known trace element, often in the body acts as a potassium synergist. The role of rubidium in the body is poorly understood. The daily requirement of a healthy adult in rubidium is about 1-2 mg, which exceeds the rate of consumption of many other trace elements. Most of the rubidium (about 40%) enters the body with drinks such as drinking water, tea and coffee. Some rubidium is found in the liver and muscles of marine fish [6]. There is a study that the level of potassium and rubidium was significantly reduced in the blood of patients with Alzheimer's disease compared to the healthy group, but the content of cerebrospinal fluid was within normal limits [10]. Experiments on animals have shown that the lack of rubidium causes a delay in fetal development, abortion and premature birth, a reduction in life expectancy [8].

In this study, the serum Nickel (Ni) content was a median of 57.08 μg/l and strontium (Sr) - 146.55 μg/l, which exceeded the norm by 2 - 3 times.

Strontium (Sr) is found in all organs and tissues, affects the processes of bone formation, the activity of enzymes of catalase, carbonic anhydrase and alkaline phosphatase. In addition, strontium ions are so close in characteristics to calcium ions that they are included in the exchange with it, but, having a greater intensity of metabolism and significantly different in size, gradually disrupt the functioning of calcium-dependent metabolic processes [8].

The content of iron (Fe) in blood serum was 5219.43 μg/l, which is 4-5 times higher than the accepted standards [11]. High iron content is associated with an increased risk of cardiovascular disease and some cancers.

The manganese (Mn) content was 130.86 μg/l, which is much higher than normal. According to the literature, there are cases of acute intoxication with manganese dust in the workplace. Excess manganese leads to increased fatigue, memory loss, depression, encephalopathy, and neurological disorders [5]. Perhaps this factor leads to mental disorders with suicidal attempts, this problem requires further study.

Microelements with a very low concentration in the studied sera were isolated into a separate group (table. 2).

Cobalt (Co) and cesium (Cs) were detected in almost all subjects, yttrium (Y) and cadmium (Cd) in half of the cases and in less than 1/5 of the cases niobium (Nb), arsenic (As), vanadium (V), thallium (Tl). The content of cobalt (Co) in Dolgans exceeded the known values many times, which requires additional in-depth study.

The analysis of the content of elements separately in men and women. At comparing by gender the median of all investigated trace elements in addition to rubidium (Rb), significant differences were not revealed. According to our data, the rubidium median (Rb) in men was significantly higher (p=0.005) and amounted to 322.95 (286.62-372.46) μg/l than in

Table 1

The content of trace elements in blood serum Dolgan, µg / l

Trace element	n	Me (Q25-Q75)	Reference values (literature data)*
Scandium (Sc)	105	13.97 (9.13-19.57)	10-40
	2	<0.001	
Titanium (Ti)	104	153.05 (83.98-265.82)	
	2	<0.001	
Chromium (Cr)	106	276.67 (246.69-324.70)	165-305
Manganese (Mn)	100	130.86 (63.88-173.25)	0-10
	5	<0.001	
Iron (Fe)	98	5219.43 (3123.30-9197.05)	600-1800
	5	<0.001	
Nickel (Ni)	83	57.08 (23.38-146.07)	1-28
	23	<0.001	
Copper(Cu)	81	1323.60 (953.07-1902.63)	750-1300
	21	<0.001	
Zinc (Zn)	93	1076.11 (677.48-1686.24)	543-1130
	12	<0.001	
Rubidium (Rb)	105	299.45 (264.35-346.34)	230-270
	2	<0.001	
Strontium (Sr)	87	146.55 (77.99-234.11)	44-64
	18	<0.001	
Lead (Pb)	70	9.48 (3.61-23.75)	< 25
	33	<0.001	

Note. In the Tables 1 and 2 n - number of observations
Me (Q25-Q75) - median (interquartile range 25 and 75)
*AMAP Assessment 2002: Human Health in the Arctic // Arctic Monitoring and Assessment Programme (AMAP) - Oslo, Norway, 2003

women - 292.92 (256.21-332.60) µg/l.

The subjects were divided into three groups by age: the first group of young people – from 20-44 years, the second group of middle age – from 45-59 years and the third group of elderly people over 60 years.

The phosphorus content in the age groups in men and women did not differ significantly, despite an increase in the average age in both sexes.

According to the literature, serum iron should be higher in men. In this study, the iron content in women was higher, although statistically insignificant, while increasing with age. In 12 young men, the median iron was 4.4 mg / l, the average age of 13 subjects-5, 6 mg/ l, 8 elderly-3, 3 mg/ l, on the contrary, in 31 young women-4.8 mg/ l, in the middle group of 28 subjects-6.1 mg/l and the highest rates of iron in the group of 7 women over 60 years – 9.9 mg / l (compared with the same group of men p=0.049). These indicators require extensive research.

Considered significantly high in men Dolgan element rubidium (Rb) by age groups. For all three groups in men, the serum rubidium content was expected to be higher and amounted to 13 young-321.5 µg / l, in the middle group of 13 people - 343.2 µg / l, in 9 men over 60 years-321.6 µg/l. the rubidium content was in women in the respective groups: 295.8 µg/l, 293.4 µg/l and 248.7 µg/l.

In our study 26 people had an increase in atherogenic cholesterol associated with increased levels of iron, cobalt and rubidium. According to the study, cardiovascular disease (CVD) amounted to 691 per 1000 population. It indicating a high incidence of CVD to Dolgan. At the same time, the lipid spectrum with a high coefficient of atherogenicity was observed in 1/3 of the examined patients.

Conclusion. Thus, the study revealed an increased content of many elements, including manganese, strontium, cobalt and iron in the blood, which can affect the development of diseases of the cardiovascular system and other diseases in the indigenous inhabitants of the Arctic.

REFERENCES

1. Агаджанян Н.А., Велданова М.В., Скальный А.В. Экологический портрет человека и роль микроэлементов. Москва: Изд-во КМК. 2001:236. [Agajanyan NA, Veldanova MV, Skalny AV. Ecological portrait of a person and the role of microelements. Moscow: Publishing house KMK. 2001:236. (In Russ.).]

2. Горбачев А.Л., Луговая Е.А., Скальный А.В. Биоэлементный статус аборигенных жителей северных регионов России. *Микроэлементы в медицине*. 2012;13(3):1-6. [Gorbachev AL, Lugovaya EA, Skalny AV. Bioelement status of native inhabitants of the northern regions of Russia. *Trace elements in medicine*. 2012;13(3):1-6. (In Russ.).]

3. Колпакова А.Ф. Хронические неспецифические заболевания легких и антропогенное загрязнение окружающей среды в Таймырском автономном округе: автореф. дис. … д-ра мед. наук (14.00.43). Алтайский гос. мед. ун-т. Барнаул; 1997:36. [Kolpakova AF. Chronic nonspecific lung diseases and anthropogenic environmental pollution in the Taimyr Autonomous Okrug: author's abstract dis. ... doctor of medical sciences. Altai St. Med.Uuniv. Barnaul. 1997:36. (In

Table 2

The content of ultramicroelements in blood serum Dolgan, µg / l

Trace element	n	Me (Q25-Q75)	Референсные значения (литературные данные)*
Vanadium (V)	18	4.78 (1.42-17.03)	
	88	<0.001	
Cobalt (Co)	73	4.09 (1.54-9.25)	0.05-0.1
	30	<0.001	
Arseni (As)	26	4.94 (2.88-19.58)	2 - 62
	78	<0.001	
Yttrium (Y)	58	0.80 (0.27-1.73)	
	44	<0.001	
Niobium (Nb)	35	10.07 (4.13-16.68)	
	69	<0.001	
Cadmium (Cd)	56	0.38 (0.16-0.78)	0.01-2
	48	< 0.001	
Cesium (Cs)	103	1.05 (0.69-1.39)	
	3	<0.001	
Thallium (Tl)	13	2.64 (0.29-7.14)	
	92	<0.001	

Russ.).]

4. Макаров В.Н., Шац М.М. Критерии экологического нормирования и оценка зон влияния антропогенных воздействий на динамику экосистем. Проблемы и практика экологического нормирования на Севере. Науч.-темат. пособие. Якутск: ИПЭС АН РС(Я). 2001:206-239. [Makarov VN, Schitz MM. Criteria of environmental regulation and assessment of zones of influence of anthropogenic impacts on the dynamics of ecosystems. Problems and practice of environmental regulation in the North. Scientific topics allowance. Yakutsk: IPES AN RS(Y); 2001:206-239. (In Russ.).]

5. Мельникова М.М. Интоксикация марганцем. *Медицина труда и промышленная экология.* 1995;6:21-24. [Melnikova MM. Manganese intoxication. *Labor Medicine and industrial ecology.* 1995; 6:21-24. (In Russ.).]

6. Авцын А.П. Жаворонков А.А., Риш М.А., Строчкова Л.С. Микроэлементозы человека (этиология, классификация, органопатология). Монография. Москва: Медицина. 1991:496. [Avtsyn AP, Zhavoronkov AA, Rish MA, Strochkova LS. Human trace elements (etiology, classification, organopathology). Monograph. Moscow: Medicine. 1991: 496. (In Russ.).]

7. Очелик Д.С. Топлан М.С., Акыоглу М.С. Влияние лития на содержание меди и цинка в тканях // *Микроэлементы в медицине.* 2003; 4(1):13-16. [Ochelik DS, Toplan MS, Akyoglu MS. The effect of lithium on the content of copper and zinc in the tissues. *Trace elements in medicine.* 2003; 4(1):13-16. (In Russ.).]

8. Скальный А.В. Кудрин А.В. Радиация, микроэлементы, антиоксиданты и иммунитет. Москва: Лир Макет. 2000:427 [Skalnyi AV, Kudrin AV. Radiation, trace elements, antioxidants and immunity. Moscow: Lire Layout. 2000:427 (In Russ.).]

9. Слепцов А.Н. Экологические аспекты при разработке алмазодобывающего прииска «Анабар». Проблемы и перспективы комплексного освоения месторождений полезных ископаемых криолитозоны: третий междунар. науч.-практ. конф. (Якутск, 14-17 июня 2005 г.). Якутск. 2005; 3:112-114. [Sleptsov AN. Environmental aspects in the development of the diamond mine "Anabar". Problems and prospects for the integrated development of mineral deposits in the cryolithozone: the third international. scientific-practical conf. (Yakutsk, June 14-17, 2005). Yakutsk. 2005; 3: 112-114. (In Russ.).]

10. Roberts BR. et al. AIBL research group. Rubidium and potassium levels are altered in Alzheimer's disease brain and blood but not in cerebrospinal fluid. *Acta Neuropathol Commun.* 2016; 14 4(1):119.

11. AMAP Assessment 2002: Human Health in the Arctic. Arctic Monitoring and Assessment Programme (AMAP). Oslo, Norway. 2003.

12. Walker JB et al. Maternal and umbilical cord blood levels of mercury, lead, cadmium, and essential trace elements in Arctic Canada. *Environmental Research*. 2006; 100(3):295-318.

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