N.V. Borisova, G.A. Koltovskaya, U.D. Antipina

DISTRIBUTION OF DISELEMENTOSIS AND ELEMENTAL PATHOLOGY PROFILE IN WOMEN FROM VARIOUS REGIONS OF THE REPUBLIC OF SAKHA (YAKUTIA)

DOI 10.25789/YMJ.2018.63.19

ABSTRACT

Stability of the chemical composition of the body is one of the most important and mandatory conditions for its normal functioning. Accordingly, deviations in the content of chemical elements caused by environmental, climatic-geographical factors or diseases will lead to a wide range of disorders in the state of health. Therefore, the identification and evaluation of deviations in the exchange of macro- and microelements, as well as their correction, are a promising direction of modern medicine.

The **objective** of the work is to reveal the regularity of distribution of diselementoses and the elemental profile of pathology the content of chemical elements in the hair of women from various regions of the Republic of Sakha (Yakutia).

Keywords: microelements, ecology, Yakutia, health, North.

Stability of the chemical composition of the body is one of the most important and mandatory conditions for its normal functioning. Accordingly, deviations in the content of chemical elements caused by environmental, climatic-geographical factors or diseases will lead to a wide range of disorders in the state of health. Therefore, the identification and evaluation of deviations in the exchange of macro- and microelements, as well as their correction, are a promising direction of modern medicine.

According to observations of Russian scientists, the complex of biomedical and ecological factors, strictly specific for components of both northern ecosystems and northern human populations, participates in the formation of human health in the North [1, 2, 6, 10]. These features in many components of northern ecosystems came to an optimal balance and stabilized, and in the human physiological systems, in particular in the immunogenetic apparatus, were remembered and determined. The destabilizing factor of the natural environment is technogenic and anthropogenic pollution of the biosphere [5, 7, 8].

Due to the limited northern ecosystems, the parameter of ecological capacity, as well as the slowed down rate of biological degradation of toxicants, even their minimal contents have the ability to accumulate to concentrations that are toxic to the living organism. At present, pollution of the environment with heavy metals creates serious problems for the safe agricultural use of soils near industrial cities, metallurgical enterprises and highways. Heavy metals are supplied to soils of agrocenoses with gas-dust streams, fertilizers, pesticides during irrigation, and also when sewage sludge is used as fertilizer [4, 9, 12].

The Republic of Sakha (Yakutia) is by its biogeochemical characteristics a unique region of the Russian Federation. Seasonal thawing of soils varies from a dozen centimeters in the north to 2-3 m in the south. Soils of Yakutia are characterized by a lack of calcium, phosphorus, potassium, cobalt, copper, iodine, molybdenum, boron, zinc, a sufficient amount of manganese and a relative excess of strontium, especially along river floodplains [4, 12]. Soils and bottom sediments of the Lena-Vilyui watershed are deficient in the content of copper, boron and molybdenum and are enriched in manganese, iron and cobalt [7]. Bottom deposits due to their high sorption properties can be considered as an integral indicator of anthropogenic load on the hydrosphere and their study should be given an important place in the general system of observations of the state of the aquatic environment. The composition of lake and river water in general is characterized by low mineralization and low content of fluorine, copper and molybdenum, a decrease in the intensity of water migration of zinc, manganese and copper, an increase in the migration activity of tin, vanadium and potassium. Accordingly, under such conditions, the content of calcium, phosphorus, chlorine and magnesium in the forage grasses of native plants is significantly reduced [8, 12].

The **objective** of the work is to reveal the regularity of distribution of diselementoses and the elemental profile of pathology in women from various regions of the Republic of Sakha (Yakutia).

Materials and methods of the research

Using the multielement analysis system by AES-ISP and MS-ISP methods, the content of chemical elements (Al, As, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, P, Pb, Se, Si, Sn, Ti, V, Zn , μg / g) in the hair of 555 women from various regions of the Republic of Sakha (Yakutia) was investigated.

The choice of hair as an object of analysis was due to numerous publications confirming the suitability of hair analysis to assess the elemental status of the population [3, 11].

As a reference, a hair sample from the Shanghai Institute of Nuclear Physics of the Academy of Sciences of the People's Republic of China (GBW09101) was used. For the removal of surface contamination and degreasing of hair, the method of preparation of hair samples recommended by the IAEA is applied. To do this, the hair is treated with acetone for 10-15 minutes, and then washed three times with distilled water. Hair drying is performed at room temperature for 10-15 minutes.

Standard working solutions are prepared by diluting the reference standard multielement solutions. Preparation of working standards consists in bringing an aliquot of the support solution to the required volume with dilute nitric acid or deionized water for aqueous solutions. The obtained concentrations are calculated and entered for calibration in the WinLab32 software package. The internal standard is added to the finished working standard - a solution of indium nitrate, CIn≈ [1000 mg / l], calculated at 100 μl for every 10 ml of the standard solution. Working standards are expended in 1-5 days.

A solution of SOS (a standard sample of the hair composition) is prepared from standard hair of known concentration (imported) or selected from the discharge of waste samples. Used to monitor the

correct measurement of concentrations during serial measurements, for example, every 10 measurements. A «verification standard» can also be used as a control, which is prepared on the basis of 10% (by volume) of nitric acid by adding GSO elements of known concentration.

The analysis of the samples is carried out using the ISP-AES method using the Optima 2000 DV (PerkinElmer) instrument (determination of Ca, Mg, P, Zn, K, Na), as well as the ICP-MS method using the Elan 9000 (PerkinElmer) (Al, As, Cd , Co, Cr, Cu, Fe, Mn, Ni, Pb, Se, Si, Sn, Ti, V).

Statistical processing of the data was carried out using Microsoft Excel XP and Statistica 6.0. In assessing the reliability of the differences, the value p <0.05 was used. Statistical processing of the obtained experimental material was carried out on IBM-PC using the Excel software package. The arithmetic mean (M) and its error (m), the standard deviation (), the coefficient of pair correlation (r) were calculated. Assessment of the reliability of the differences between the data obtained in the study groups was carried out according to Student's t-criterion.

Results

As shown by the analysis of the obtained data, for women living in different regions of the Republic of Sakha (Yakutia), there are significant differences in the content of chemical elements in the hair. The observed differences are mainly due to the original "elemental portrait" of residents of the polar and, to a greater extent, southern regions of the Republic, while the "elemental portraits" of residents of the western and central regions and Yakutsk are reliable there are practically no differences and they can be considered "average" for the surveyed region (Table 1).

The elemental status of women residing in the southern regions can be considered the most "peculiar": they have relatively higher content in the hair of Ca compared to other groups of areas, against the background of a relatively reduced concentration of such chemical elements as Al, Be, Cd, Cr, Li , Pb, and also Mg, K, Na and I. Thus, it can be concluded that the least common among the surveyed areas is the load of the most common toxic elements Al, Be, Cd and Pb, while the reduced content in the hair Cr and K may be considered Xia as an unfavorable factor indicates the relative lack of these elements in the body of women.

Unlike the southern regions, the female population of the Arctic regions is characterized by the maximum content in the hair of toxic chemical elements Cd, Hg, Pb, Mn. Attention is also drawn to the highest concentration in the hair of Fe (although no significant differences were established).

Residents of the central regions are characterized by a relatively high content of Ca, Mg and LI hair, and western groups of uluses - high content of Al.

The relatively high content of Ca and Mg women in hair is probably of purely physiological character. According to modern data [15], the average content of these elements in women's hair is significantly higher than that of men.

The discussion of the results

The obtained results at comparing the hair composition of the female population of the central regions of the Republic Sakha (Yakutia) and Yakutsk seem to be the result of a high degree of urbanization, which significantly changes the natural elemental balance of population groups, including women (the population of the arctic, western and southern areas in the vast majority rural).

In order to reveal the most characteristic features of the "elemental portrait" of the female population of the Republic of Sakha (Yakutia), we estimated the frequency of the deviation of the content of chemical elements in the hair from the norm boundaries [13, 14, 16]. The data presented that, there is a significant difference between the frequencies of imbalances of chemical elements in the hair of women from different regions of the Republic of Sakha (Yakutia) (Table 2 - 3)

A number of imbalances (deficiencies or excesses) in the content of chemical elements in hair have been established, characteristic for all the surveyed groups of areas. Thus, for women, regardless of their place of residence, there is a relatively lower content of Ca, Co, Mg (excluding central regions), P, Se and Zn and a relatively high content of Mn and Na (in all groups of regions, the frequency of deficit / excess of these elements in the hair exceeded 30%).

The individual features of elemental portraits of groups of regions as a whole correspond to those established in the analysis of the absolute content of chemical elements in women's hair. Thus, for residents of the Arctic regions, the fre-

Table 1

Average content of chemical elements in the hair of women living in different regions of the Republic of Sakha (Yakutia), µg / g

Element	Regions of the Republic of Sakha (Yakutia)					Reliable differences between districts **
	arctic n = 61	western n = 120	southern n = 151	central n = 121	Yakutsk * n = 102	
Al	8,51±0,57	14,2±2,05	4,74±0,59	4,71±0,32	9,64±1,04c,d	4, 5
As	0,05±0,005	0,1±0,056	0,05±0,009	0,03±0,004	0,07±0,017	
B	1,79±0,36	0,98±0,17	1,21±0,51	1,14±0,19	0,8±0,14a	
Be	0,01±0,001	0,01±0,001	0,003±0,001	0,01±0,001	0,01±0,001c	2, 4
Ca	559±49	853±108	1525±130	2162±526	1700±186a,b	2, 3, 4, 5
Cd	0,14±0,02	0,06±0,01	0,03±0,001	0,04±0,01	0,08±0,01a,c	1, 2, 3, 4
Co	0,04±0,01	0,04±0,01	0,03±0,01	0,03±0,01	0,05±0,01c	
Cr	0,61±0,04	0,53±0,04	0,36±0,03	0,46±0,06	0,52±0,05c	2, 4
Cu	11,83±0,29	10,94±0,25	12,07±0,51	9,94±0,44	13,37±0,91b	
Fe	46,85±9,64	21±2,37	35,44±16,89	15,7±1,46	25,06±1,53a,d	
Hg	2,72±0,42	0,74±0,08	0,68±0,04	0,66±0,13	1,2±0,2a,b,c	1, 2, 3
I	5,98±4,97	1,3±0,18	0,78±0,12	0,85±0,19	2,11±0,56c	2
K	830±190	543±102	217±121	255±70	295±52a,b	2
Li	0,05±0,005	0,05±0,01	0,02±0,003	0,16±0,053	0,09±0,026c	3, 5, 6
Mg	82±8	155±23	99±12	586±105	191±23a,c,d	3, 5, 6
Mn	4,17±0,44	1,8±0,27	2,19±0,23	1,81±0,26	2,62±0,27a,b	1, 2, 3
Na	1332±292	847±150	444±181	1027±209	527±126a	2
Ni	0,49±0,06	0,38±0,05	0,52±0,07	0,41±0,07	0,57±0,05b	
P	140±4	168±6	165±16	147±5	217±61	
Pb	3,82±0,64	1,45±0,22	0,43±0,06	1,52±0,57	2,2±0,54c	1, 2, 3, 4
Se	0,39±0,05	0,49±0,09	0,54±0,05	0,23±0,05	0,39±0,04c	
Si	19±2,04	48±7,31	50,9±8,37	45,81±9,03	49±6,64a	
Sn	0,32±0,06	0,25±0,05	0,30±0,05	0,38±0,07	0,63±0,11a,b,c	
V	0,05±0,01	0,07±0,01	0,06±0,01	0,04±0,01	0,06±0,01	
Zn	195±10	167±5	177±4	177±10	195±8b,c	1

Note. In the Tables 1-3 * reliable differences in comparison with Yakutsk: a - arctic regions, b - western regions, c - southern regions, d - central regions
** 1 - arctic / western; 2 - arctic / southern; 3-arctic / central
4 - western / southern; 5 - west / central; 6 - south / central.

quency of excessive accumulation in the hair of both essential (Cr, Fe, K, Mn, Na, Zn) and toxic (Cd, Hg, Pb) chemical elements is characteristic of the inhabitants of the Arctic regions as compared with other regions. As a result, the reduced content of Cu, Cr, Fe, K is relatively less common here, and relatively more often, the reduced content of Ca, Mg and Si.

The southern zone can be considered the most "element-deficient" group of regions, which also corresponds well with the results obtained on the basis of the analysis of absolute values. In the southern regions, the most extensive group of chemical elements is established, whose content in the hair of the examined women is below the norm limits. Among these can be classified as Ca, Co, Cr, Cu, Fe, I, K, Li, Mg, P, Se, Si and Zn. At the same time, the increased content of chemical elements in hair, with the exception of the excess of Mn and Na already described, is not characteristic of the "elemental portrait" of local women.

The regions of the Republic of Sakha (Yakutia), which are part of the western zone, differ and fully correspond to the general indices given at the beginning of the section, except for the increased content in hair Si, Fe and P, and also lower - Co and Mn, which here is more common (32, 21, 29, and 71 and 25%, respectively). The deficit in the hair I is relatively less pronounced in the local female population (38% vs. an average of 70-80% in other regions).

Women from the central regions of Yakutia are characterized by relatively high frequencies of excess accumulation in hair Ca, Mg, Cd, Na, Li, Pb and decreased - Cr. It is interesting to note that the reduced content of electrolyte elements K, Na, and Li in hair is not found at all here, but deficiencies in hair of Fe, Cu and Zn are widespread. As can be seen from the above data, the central regions of the Republic of Sakha (Yakutia) have a number of features characteristic of both polar (the prevalence of excess accumulation of Cd, Pb toxicants) and other areas (widespread prevalence of essential chemical element deficiencies), that is, the greatest imbalance in elemental metabolism .

The urban population (Yakutsk) differs from the other surveyed groups of areas with a relatively higher frequency of reduced Se, but deficiencies in the hair of Ca, Mg and P are less common here. On the contrary, there are abundant Ca and Mg excesses with a sufficiently high frequency, the accumulation of Mn and Sn is more typical for the population.

Thus, the observed regularity (the

Table 2

Frequency of the increased content of chemical elements in the hair of women in the Republic of Sakha (Yakutia), depending on the place of residence, %

Element	Regions of the Republic of Sakha (Yakutia)					Reliable differences between districts **
	arctic n = 61	western n = 120	southern n = 151	central n = 121	Yakutsk * n = 102	
Al	3,28	5,83	2,00	0,00	5,88	
As	0,00	0,85	0,00	0,00	0,98	
B	4,76	0,00	1,54	0,00	2,04	
Be	0,00	0,00	0,00	0,00	0,00	
Ca	0,00	10,00	18,00	23,81	23,53a,b	3
Cd	21,31	1,67	4,67	28,57	9,90b,c	1, 2
Co	0,00	0,83	1,33	0,00	1,96	
Cr	21,31	15,83	4,00	4,76	10,78a	2, 4
Cu	3,28	4,17	7,33	0,00	7,84	
Fe	40,98	21,67	6,67	0,00	22,55a,c,d	1, 2, 3, 4
Hg	37,29	2,80	2,14	4,76	16,48a,b,c	1, 2, 3
I	9,09	10,53	2,17	0,00	15,28d	
K	75,41	47,50	21,33	47,62	37,25a,c	1, 2, 3, 4, 6
Li	0,00	3,45	1,33	42,86	6,86	3, 5, 6
Mg	6,56	25,00	13,33	76,19	31,37a,c,d	1, 3, 5, 6
Mn	72,13	35,83	38,00	47,62	58,82a,b,c	1, 2
Na	78,69	45,00	28,00	90,48	43,14a,c,d	1, 2, 5, 6
Ni	4,92	2,59	7,33	4,76	9,80	
P	8,20	29,17	14,67	19,05	21,57a	1, 4
Pb	32,79	7,50	3,33	28,57	12,75a,c,d	1, 2, 5, 6
Se	1,64	2,59	2,00	0,00	0,00	
Si	6,56	32,48	27,33	19,05	26,47a	1, 2
Sn	3,28	1,74	4,00	4,76	12,87a,b,c	
V	4,92	5,04	11,33	9,52	2,97c	
Zn	34,43	8,33	7,33	9,52	18,63a,b,c	1, 2, 3

Table 3

Frequency of reduced content of chemical elements in the hair of women in the Republic of Sakha (Yakutia), depending on the place of residence, %

Element	Regions of the Republic of Sakha (Yakutia)					Reliable differences between districts **
	arctic n = 61	western n = 120	southern n = 151	central n = 121	Yakutsk * n = 102	
Al	1,64	6,67	1,33	0,00	12,75a,c,d	
As	0,00	0,00	0,00	0,00	0,00	
B	0,00	0,00	0,00	0,00	0,00	
Be	0,00	0,00	0,00	0,00	0,00	
Ca	68,85	55,00	36,00	23,81	27,45a,b,c	2, 3, 4, 5
Cd	0,00	0,00	0,00	0,00	0,00	
Co	63,93	70,83	48,67	19,05	40,20a,b,c,d	2, 3, 4, 5, 6
Cr	3,28	34,17	31,33	4,76	12,75a,b,c,d	1, 2, 5, 6
Cu	18,03	35,83	48,00	76,19	21,57b,c,d	1, 2, 3, 5, 6
Fe	1,64	27,50	27,33	33,33	11,76a,b,c,d	1, 2, 3
Hg	0,00	0,00	0,00	0,00	0,00	
I	72,73	38,60	78,99	61,90	68,06b,c	1, 4, 5, 6
K	1,64	19,17	32,67	0,00	30,39a,b,d	1, 2, 4, 5, 6
Li	14,75	6,03	51,33	0,00	9,80c,d	2, 4, 6
Mg	47,54	36,67	55,33	4,76	20,59a,b,c,d	3, 4, 5, 6
Mn	3,28	25,83	3,33	0,00	4,90b	1, 4, 5
Na	4,92	15,83	13,33	0,00	4,90b,c	1, 5, 6
Ni	0,00	0,00	0,00	0,00	0,00	
P	42,62	20,00	46,00	42,86	33,33a,b,c,d	1, 4, 5
Pb	0,00	0,00	0,00	0,00	0,00	
Se	29,51	38,79	32,67	66,67	48,04a,b,c,d	1, 3, 5, 6
Si	39,34	25,64	26,00	9,52	22,55a	1, 2, 3, 5, 6
Sn	0,00	0,00	0,00	0,00	0,00	
V	0,00	0,00	0,00	0,00	0,00	
Zn	40,98	45,83	55,33	71,43	42,16c,d	2, 3, 5, 6

increase in the intake of chemical elements in the organism of the women of the Republic of Sakha (Yakutia) towards the south-south), established in the analysis of the absolute content of chemical elements in the hair of the adult population, is generally confirmed, as in the analysis of the frequency of imbalances, established using the boundaries of the normal content of chemical elements in human hair. However, in the latter case, the peculiarities of the elemental balance of the population of the central regions of the Republic of Sakha (Yakutia) are becoming noticeable, breaking out their reduced scheme. The high frequency of excessive accumulation here of a number of chemical elements makes these regions related to the Arctic.

By analogy with the above data on the difference in the elemental composition of the hair of women (expressed in absolute figures), we also performed an analysis of the differences in the frequency of imbalances in the content of chemical elements in the hair of the examined.

For women living in the central regions of Yakutia, the risk of hyperelementosis of such essential elements of Ca, Mg and Na is more typical. At the same time, women are characterized by a relatively high frequency of reduced content in hair of essential chemical elements. Thus, residents of the Arctic regions of Yakutia are more often found to have deficiencies of Ca and Mg; southern regions - Cr, P and Zn, the western group of areas - Cr, the central regions - P, Se, Zn, Yakutsk - P, Se and Zn.

The conclusion

The obtained results show that the risk of hyperelementosis in the female population of the Republic of Sakha (Yakutia) is significantly increasing in the direction of south-south; in the direction of north-south the risk of development of hypo-elemental diseases increases significantly. At the same time, the central regions of the republic are an exception to the general scheme: the prevalence of excessive accumulation in the hair as toxic and essential chemical elements is also great here, as in the arctic regions of the republic.

The imbalance of elements, regardless of its causes, can be an independent pathogenetic factor, since the most important role of macro- and microelements in the processes of vital activity of the organism is known. Therefore, the current stage of development of the pathogenesis of various diseases and intoxications requires the study of pathological processes at cell levels, subcellular structures, membrane and enzyme systems.

References

1. Agadzhanyan N.A. Veldanova M.V. Skalny A.V. Jekologicheskiy portret cheloveka i rol' microelementov [Ecological portrait of a person and the role of microelements]. Moscow: Izd-vo KMK [Publishing house KMK], 2001, 236 p.
2. Agadzhanyan N.A. Etnicheskie problemy adaptacionnoy fiziologii [Ethnic problems of adaptive physiology]. Moscow: Izd-vo RUDN [Publishing House of the Peoples' Friendship University of Russia], 2007, 57 p.
3. Borisova N.V. Mediko-fiziologicheskoe obosnovanie adaptivnyh reakcij organizma studentov v jekstremal'nyh uslovijah Jakutii: avtoreferat dis. … doktora medicinskih nauk: 14.03.03, 03.03.01 [Medico-physiological substantiation of adaptive reactions of an organism of students in extreme conditions of Yakutia: the author's abstract of the dissertation. ... doctor of medical sciences: 14.03.03, 03.03.01]. Mesto zashhity: Yakutsk, GOU VPO «Jakutskij gosudarstvennyj universitet» [Place of defense: Yakut State University], 2011, 218 p.
4. Gudkov A.B. Popova O.N. Lukmanova N.B. Jekologo-fiziologicheskaja harakteristika klimaticheskih faktorov Severa: obzor literatury [Ecological and physiological characteristics of climatic factors of the North: review of literature]. Jekologija cheloveka [Ecology of man], 2012, №01, pp.12-17.
5. Kaznacheev V.P. Problema adaptacii cheloveka [The problem of human adaptation]. Novosibirsk: Nekotorye itogi i perspektivy issledovanij [Some results and prospects of research], 1978, 56 p.
6. Avtsyn A.P. Zhavoronkov A.A. Rish M.A. [et al.] Mikroelementozy cheloveka: etiologia, classificacia, organopatologiya [Microelementoses of man: etiology, classification, organopathology]. Moscow: Medicina [Medicine], 1991, 496 p.
7. Borisova N.V. Antipina U.D. Markova S.V. [et al.] Rol' elementnogo disbalansa v razvitii otdelnyh patologij u detej Vilyiskogo regiona [The role of elemental imbalance in the development of individual pathologies in children in the Vilyui region]. Jakutskij medicinskij jurnal [Yakut Medical Journal], 2016, № 3 (55), pp.46-49.
8. Savvinov D.D. Sazonov N.N. Microelementy v severnyh ecosistemah [Microelements in northern ecosystems]. Novosibirsk: Nauka, 2006, 208 p.
9. Skalnaya M.G. Gigienicheskaya ocenka vliyania mineralnyh componentov raciona pitaniya i sredy obitaniya na zdorovie naseleniya megapolisa: avtoref. dis. … doktora med.nauk [Hygienic assessment of the effect of the mineral components of the diet and the habitat on the health of the population of the megalopolis: author's abstract. dis. ... doctor med. sciences]. Moscow: 2005, 42 p.
10. Skalny A.V. Himicheskie elementy v fiziologii i jekologii cheloveka [Chemical elements in human physiology and ecology]. Moscow: Izdatelskij dom «Onix 21 vek»: Mir [The publishing house „Onyx 21 century": Mir], 2004, 216 p.
11. Skalny A.V. Ustanovlenie granits dopustimogo soderjania chimicheskih elementov v volosah detey s primeneniem tsentilnyh chkal [Establishment of the limits of the permissible content of chemical elements in children's hair using centile scales]. Vestnik S-Peterburgskoy GMA im. I.I. Meshnikova [Herald of the I. I. Mechnikov St. Petersburg State Medical Academy], 2002.-№1-2 (3), pp.62-65.
12. Skalny A.V. Jekologo-fiziologicheskoe obosnovanie effektivnosti ispolzovaniya macro- i microelementov pri naruchenyah gomeostaza u obsleduemyh iz razlichnyh klimatogeographicheskih regionov: diss.… dokt.med.nauk [Ecologic-physiological substantiation of efficiency of use of macro - and microelements at disturbances of a homeostasis at surveyed from various climatogeographical regions: diss. ... doctor med. sciences]. Moscow: 2000, 352 p.
13. Skalny A.V. Bykov A.T. Jekologo-fiziologicheskie aspekty primeneniya macro- i microelementov v vosstanovitelnoy medicine [Ecological and physiological aspects of the application of macro- and microelements in restorative medicine]. Orenburg: RIK GOU OGU [REC of GOU OSU], 2003, 198 p.
14. Skalny A.V. Rudakov I.A. Bioelementy v medicine [Bioelements in medicine]. Moscow: Izdatelskij dom «Onix 21 vek»: Mir [The publishing house „Onyx 21 century": Mir], 2004, 272 p.
15. Borisova N. V. Petrova P.G. Markova S.V. Imbalance of Macro- and Micronutrients in the Environment and Biosubstrates of Residents Living in the Diamond Mining region of Yakutia. International Journal of Biomedicine, 4 (3), 2014, New York, pp.179-181.
16. Meissner D. Evaluation of trace elements status using biochemical indicators, 1993, pp.1074–1078.

The authors

Medical Institute NEFU, Yakutsk, Russia:

1. Borisova Natalia Vladimirovna - doctor of medical sciences, professor of the Department Normal and pathological physiology, email: borinat@yandex.ru;
2. Koltovskaya Galina Aleksandrovna - Postgraduate Student, Normal and Pathological Physiology, e-mail: koltov79_galya@mail.ru;
3. Antipina Ulyana Dmitrievna - Candidate of Medical Sciences, Associate Professor of the Normal and Pathological Physiology Department.