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Elemental Blood and Hair Composition of the Russian North Native Inhabitants with Different Biogeochemical Environment

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Abstract

Elemental composition has been studied for the blood of Chukchi people living in the continental part of Chukotka, and Eskimo people living at the coast of the Bering Bay, as well as for a group of Novosibirsk townspeople. Elemental composition has been determined for the hair of the Chukchi and Yakut people living in the continent. Using the Synchrotron Radiation X-ray Fluorescence Analysis (SR XFA) technique, a simultaneous determination of chemical elements in the blood of the mentioned populations has been performed, as it follows: K, Ca, Fe, Cu, Zn, Ge, Se, Br, Rb, Sr, Zr, Pb. The technique potentialities of determining the concentration of chemical elements in the hair of some groups of Yakut and Chukchi men and women using XPA SR have allowed detecting simultaneously K, Ca, Ti, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Y, Zr, Mo, Hg, Pb, Bi. Individual, sexual and regional differences in the concentration of elements in blood and hair of the populations under investigation have been established. The data obtained have allowed us to estimate the level of elemental exchange for some groups of Chukchi, Yakut, Eskimo people, to reveal the features of elemental distribution, as well as to perform a certain biogeochemical characterization of the environment.

Key words: elemental composition, SR XPA, blood, hair, populations

INTRODUCTION

Long-term studies on the chemical composition of biosphere have revealed its exclusive heterogeneity in various regions of our planet. According to modern concepts, the process of functioning and adaptation of an organism with respect to environmental conditions is to the utmost determined by biogeochemical factors, by supplying a human with necessary nutrients including macro- and microelements those use to compose important biologically active substances or to activate them in the course of metabolism [1, 2].

The fact is proved that the quantitative content of microelements in a human organism is directly dependent on their concentration in various components of the environment such as soil-forming rocks, soils, naturally occurring waters, atmospheric aerosols [3]. The chemical composition of organisms uses to change depending on the environmental composition; however, it is much more stable owing to the regulatory processes of homeostasis (relative constancy of internal environments). One of the major and obligatory conditions for normal functioning organisms including human ones consists in the stability of chemical composition differing for different areas of the terrestrial globe.

In order to study the microelemental exchange in populations it is not enough to have in avail data concerning the characteristics of environment, carrying out the analysis of human tissues human is also required. Nowadays

hair and blood are considered to be the most informative biosubstrates for the estimation of the elemental status of an individual and a population, as well as the participation of elements in the formation of the ecological portrait of inhabitants of some regions with different biogeochemical conditions. Just the data concerning the elemental composition of these substrata could become critical for determining the level of geochemical factor influence upon a human population. An extensive material is accumulated concerning the content of microelements in blood [2, 4–9] and hair [2, 4–8, 10, 11] for the inhabitants of different territories, however there are scarce data available from the literature concerning the microelemental exchange in a human organism under the conditions of the North. At the same time, there is a considerable need for such data concerning the influence of the biogeochemical panorama of the North upon the indigenous population.

Pursuing our works [12–14] concerning the creation of the base of knowledge on the elemental composition for various biological systems, the revealing of the regional features of the accumulation of chemical elements, we have determined the elemental composition of blood for Chukchi people living in the continental part of Chukotka, for the Eskimo people living at the coast of the Bering Bay, and for a group of people living in Novosibirsk (reference group). The concentration of elements in hair has been measured foe Chukchi and Yakut people. Comparison of the results obtained have been compared taking into account different biogeochemical environment.

The indigenous small peoples of the North living in an isolate under extreme conditions of high longitudes, who adapted to the environment during a long evolutionary time, developed an especial strategy of behaviour with respect to the environment. The inhabitation regions Yakut, Chukchi and Eskimos represent a typical example of a natural extremal zone, where the climatic, geochemical, economic and cultural factors play a significant role. The prevalence of low mid-annual temperatures, high wind speed, an increased soil acidity (as a rule, tundra soils) are the main environmental factors of the North, which indicates a considerable mobility of chemical elements and their low assimilability by living organisms.

Under these conditions, a type of management was formed with a high calorie diet (proteins, fats), promoting the conservation of the population homeostasis. From the economic standpoint Yakut people are hunters of the taiga zone, Chukchi people are nomadic reindeer farmer of tundra and forest-tundra, whereas Eskimo people are hunters for sea animals. Tundra populations (Yakut and Chukchi people) use for food more horse-flesh, venison, whereas coastal people use for food prevalently meat and fat of sea, coastal and land biological species. The use of biological resources represents a core of all the economy and culture of northern peoples. Native inhabitant peoples always lived at the expense of land and sea resources, therefore the originality of the protein and lipid exchange inherent in the natives of the North determines the features of the microelemental exchange, too [15, 16].

For example, a lot of polyunsaturated carboxylic acids is supplied with the traditional food of natives into their organisms, which prevents the excessive increase in the amount of lipids in blood. The atherosclerosis in northerners with the traditional mode of life is distributed much less as compared to the population of cities. One should not underestimate the value of plants in traditional cuisine of the North natives. An organism is supplied by cellulose and vitamins from plants, therefore the use of tundra plants, as well as various seaweed species (by Eskimo people) represents a necessary element of northerners' nutrition culture [17].

A stream of European technologies rushed into the life of northern territories weakens the skills of survival accumulated for millennia with no use of modern means. Nowadays the traditional nutrition modes of the indigenous population of the North are transformed to a considerable extent. The reasons consist in the complex changes in social, economic and ethnic stratification of the "traditional" society as well as in naturally occurring factors (the pollution of the natural environment, the reduction of traditional nature management, exhaustion of resources). The urbanization and the impact the "western mode of living" are combined with

an increase in the use of purchased food in the diet of native inhabitants.

Decreasing the contribution of sea animal meat and fat in the diet of Chukchi and Eskimo people breaks the naturally occurring exchange of macro- and microelements, which results in reducing the organism's ability with respect to adaptation and, as consequence, to worsening the health of population. At the population level, this fact could cause the deterioration of demographic parameters for the status of the population as a whole. Passing to the European type of food exerts an especially adverse effect on physical growth and development of Yakut, Chukchi and Eskimo children [18, 19]. The residence territory of Chukchi, Yakut and Eskimo people does not belong to the zones with a high man-caused loading.

However, experimental data demonstrate that a significant part of atmospheric pollution of the Arctic regions is connected with aerosol emission from large-scale industrial centres located in the territory of Ural, Kazakhstan and Siberia [20]. Worsening the environmental conditions affects small northern populations owing to their special ecological vulnerability and nowadays could threaten their well-being and even existence. However, this time the sense and essence of the ethnogeny processes in the Chukotka remain the same, as it was always: adaptation ito severe conditions of life.

MATERIALS AND METHODS

Sample preparation

The samples of peripheral blood and hair were gathered in the course of expeditions organized by the SB RAS and the Scientific Research Institute of Therapy, SB RAMS. We investigated the whole blood from 73 women and 33 men of Chukchi people and from 21 women and 15 men of Eskimo people). For comparing the elemental blood composition of the mentioned nationalities we used the blood of 38 men and 12 women living in the Novosibirsk (open population, reference group). The samples of hair were selected from 60 Chukchi and 20 Yakut people. The groups under investigation were presented by Chukchi people from the tundra settlement of Kanchalan (the Anadyr District) typical for Chukotka, Yakut people from the Ust-Aldan uluss (Republic Saha), Eskimo people from the settlement Novoye Chaplino (the Provideniye Bay). The age of the inhabitants under investigation amounted to 25–60 years.

We described in detail the preparation process for blood and hair samples in papers [12, 13]. Blood was taken from a finger (25 μL) and was then inmediately put on a filter (Whatman grade 41), 1 cm^2 area. The samples were dried in air and put between two layers Teflon film (d = 0.005 mm), spanned on Teflon frame. The samples of hair for the analysis were gathered from several sites of the occipital part of a head, washed by absolute acetone for degreasing and removing external extraneous inclusions [21]. Hair was analyzed in the form of tablets of 1 cm in diameter 10–40 mg in mass.

Analysis of samples

The elemental composition of blood and hair was determined employing the method X-ray fluorescence analysis with the use of synchrotron radiation (SR XFA) at the Elemental Analysis Station of the Budker Institute of Nuclear Physics, SB RAS (VEPP-3 storage unit) [22]. Owing to a high intensity of synchrotron radiation, with the use of this method one can determine a great number of chemical elements in samples with small mass, without any destruction, simultaneously within a short time. Samples were investigated at the excitation energy ranging within 19–22 keV. The processing of X-ray emission spectra was carried out with the help of Axil software.

For obtaining quantitative elemental composition for blood and hair, we employed a technique with the use of thin standard (not adequate with respect to a sample under investigation) [12, 13, 23, 24]. An algorithm has been developed and a program has been created those allow one to obtain data concerning the concentration the elements under determination. The accuracy of the analysis was provided by 20 parallel measurements for one sample ranging within 3–30 % depending on an element.

Statistical treatment of experimental data

For the analysis of the obtained information concerning the elemental composition of biosubstrate samples, one should have data on statistical characteristics of concentration change. One of the features of biosubstrates consists in a wide range of varying the concentration. Real statistical data on the objects under study in many cases exhibit distinct enough qualitative attributes those could be contradictory with respect to the shape of normal distribution such as the symmetry of the probability density function with respect to the mean value. Earlier we have demonstrated [25] that the distribution of elemental concentration values measured for biosubstrates is asymmetric. We proposed a technique for the description of experimental analytical data with use of an integrated function, the advantage of this method have been demonstrated.

For each element, we determined the geometrical mean value of the elemental concentration ($<x_i>$) and the standard geometrical deviation of the concentration logarithm for each chemical element (σ_{gi}), which characterizes the variability of concentration values. The value of σ_{gi} could be used to judge how many times is the detection probability changed for a particular value of the concentration of each element. Quantitative intra- and inter-group differences in elemental concentration for blood and hair were estimated using Student's t-criterion. The differences between parameters were calculated with 95 % significance at $t > 2.3$ [26]. Statistical characteristics were determined with the use of Microsoft Excel software package.

RESULTS AND DISCUSSION

Elemental composition of Chukchi, Eskimo people and reference group blood

With the use of SR XFA technique, we have measured simultaneously the concentration in blood of such elements as K, Ca, Fe, Cu, Zn, Ge, Se, Br, Rb, Sr, Zr, Pb for the inhabitants of the Chukotka and the representatives of reference group. Values of concentration for the majority of the measured elements range above the detection limit. The detection limit for thin samples of blood amounted to, μg/mL: K 8.0, Ca 5.6, Fe 0.2, Cu 0.12, Zn 0.08, Ge 0.04, Se 0.06, Br 0.06, Rb 0.06, Sr 0.06, Zr 0.03, Pb 0.1.

The results concerning the elemental composition of blood of the groups under investigation are presented in Tables 1, 2. It is seen that the variations of concentration for some

TABLE 1

Elemental blood composition for Chukchi, Eskimo and reference group men, μg/mL

Element	Reference group		Chukchi men		Eskimo men	
	$<x_i>$ (σ_{gi})	n_i	$<x_i>$ (σ_{gi})	n_i	$<x_i>$ (σ_{gi})	n_i
K	890 (1.2)	38	950 (1.2)	33	1195 (1.2)	15
Ca	79 (1.3)	36	67 (1.4)	33	52 (1.5)	15
Fe	467 (1.2)	38	370 (1.2)	33	300 (1.2)	15
Cu	1.0 (1.7)	36	2.6 (1.2)	33	2.8 (1.3)	15
Zn	7.1 (1.3)	38	6.7 (1.2)	33	7.0 (1.4)	15
Ge	0.1 (2.0)	15	0.07 (1.7)	16	n/d	
Se	0.1 (1.7)	32	0.1 (1.9)	31	0.28 (2.1)	15
Br	4.4 (1.4)	38	2.5 (1.3)	33	2.5 (1.3)	15
Rb	1.9 (1.2)	38	2.3 (1.5)	33	1.1 (1.4)	15
Sr	0.1 (1.8)	32	0.14 (1.7)	29	0.11 (1.5)	15
Zr	0.03* (2.0)	21	0.04 (1.6)	20	0.03* (1.5)	12
Pb	0.3 (2.4)	23	0.28 (1.8)	20	0.3 (1.5)	15

Notes. 1. $<x_i>$ is geometrical mean value for the concentration of an element; σ_{gi} is root-mean-square deviation $\ln <x_i>$; n_i is the number of fixed concentration values used for averaging. 2. n/d – not detected.

*At the detection limit.

measured elements are significant. Individual, sexual and regional differences in the content of elements for populations under investigation are revealed.

The comparative analysis of the content of chemical elements (by *t*-criterion) in blood of Chukchi men and women has demonstrated that the concentration of five elements (K, Fe, Cu, Zn, Rb) from 12 exhibit a significant difference; the content these elements in the blood of men being higher. In the blood of Eskimo men and women there is no difference observed in the concentration of the measured elements. Sexual distinctions in the reference group are manifested in the data concerning the concentration of K, Ca, Fe, Cu, Rb. The level of K, Ca, and Cu content in the blood of women is higher, whereas the content of Fe, Rb therein is lower than in blood of men. It should be noted that Ge is registered in the blood of 39 % of men from the reference group.

The age changes in the elemental composition of blood have been observed by the example of three age groups (25–34, 35–44, 45–65 years) of Chukchi men and women. No significant difference by *t*-criterion were revealed comparing the elemental concentration in blood of women and men for these groups. An exception is presented by the concentration of Sr in blood of men whose significance grows with age.

Intergroup comparison of elemental blood composition for Chukchi, Eskimo and reference group men. In comparison the concentration of elements in blood by *t*-criterion, a significant difference in K, Se and Rb is observed for Chukchi and Yakut men and women. The content of K, Se is higher, and the content of Rb is lower in blood of Eskimo people, than those in blood of Chukchi (both men and women). Statistically significant concentration differences in blood of Chukchi and Eskimo men have been revealed for Fe (for Chukchi people it is higher), whereas in blood of women for these populations significant differences were revealed for Cu (for Eskimo people it is higher).

The comparative analysis of the elemental composition of blood for "conditionally healthy" men of the reference group and for Chukchi and Eskimo men group demonstrates that concentration of Fe, Cu, Br and Rb (see with Table 1) are significantly different. So, the concentration of Fe and Br in blood is higher for men from the reference group, whereas Cu concentration is higher for Eskimo men, and Rb concentration is higher for Chukchi men. Significant difference in K, Ca and Se concentration in blood is inherent in reference group and Eskimo men. K and Se concentration in blood is higher for Eskimo men, whereas Ca concentration is higher for reference group men.

TABLE 2

Elemental blood composition for Chukchi, Eskimo and reference group women, μg/mL

Element	Reference group		Chukchi women		Eskimo women	
	$<x_i>$ (σ_{gi})	n_i	$<x_i>$ (σ_{gi})	n_i	$<x_i>$ (σ_{gi})	n_i
K	1140 (1.2)	12	850 (1.2)	73	1126 (1.6)	21
Ca	92 (1.1)	12	68 (1.3)	73	67 (1.4)	21
Fe	390 (1.1)	12	310 (1.2)	73	316 (1.2)	21
Cu	2.2 (1.6)	12	2.3 (1.3)	72	2.6 (1.2)	21
Zn	6.2 (1.3)	12	5.9 (1.2)	73	7.0 (1.4)	21
Ge	0.03 (1.4)	4	0.08 (1.7)	30	n/d	
Se	0.08 (1.3)	12	0.1 (1.6)	71	0.28 (1.7)	21
Br	3.6 (2.2)	12	2.2 (1.4)	73	2.8 (1.6)	21
Rb	1.6 (1.1)	12	1.4 (1.3)	73	0.9 (1.6)	21
Sr	0.12 (1.5)	12	0.12 (1.6)	69	0.12 (1.6)	21
Zr	0.03* (1.9)	6	0.04* (1.9)	43	0.05 (1.8)	18
Pb	0.18 (2.4)	9	0.25 (2.0)	50	0.3 (1.8)	16

Note. For design. see Table 1.

Intergroup comparison of elemental blood composition for Chukchi, Eskimo and reference group women. A significant difference in K, Cu, Zn Se, and Rb concentration in blood by *t*-criterion is inherent in Chukchi and Eskimo women. The concentration of the majority of elements in Eskimo women blood is higher, than in Chukchi women blood, except for Rb.

The comparative analysis of the measured elemental concentrations in blood of the women of northern populations and reference group women (open population) by *t*-criterion demonstrates that the content of Ca, Fe, Se, Rb significantly differs for all the populations under investigation (see Table 2). The concentration of the mentioned elements in blood is higher for reference group women, except for Se whose content is much higher in the blood of Eskimo women. A significant difference in K content in blood is inherent in reference group women and Chukchi women.

Thus, one could reveal some features in elemental distribution for Chukchi and Eskimo men and women blood. It is seen that Eskimo and Chukchi people suffer from Fe deficiency since the concentration of this element is lower comparing to that for the inhabitants of Novosibirsk and the population of other countries [4, 8, 9].

It should be noted that a good supply with such vitally important element as Se is observed for Eskimo men and women living on coast, whose concentration in blood to a considerable extent exceeds the values available from the literature and the data for Chukchi people and the representatives of reference group. To all appearance, this fact could be connected with actively using by Eskimo people for food a variety of sea products enriched with this element.

The toxic metal Pb is found out in Chukchi men and women blood for 60–68 % representatives, for Eskimo people this value amounts to 60–76 %, for the representatives of the reference group that is equal to 65–75 %. The average concentration of this element in the blood of many people from the groups under investigation such as Eskimo and Chukchi men and women as well as reference group men is slightly higher comparing to the literature data, which could adversely affect the population [4, 28].

Elemental composition of Chukchi and Yakut people hair

The legitimacy and the efficiency of using human hair as an indicator testing system for the estimation of environmental conditions, as well as a quantitative indicator of the content of some elements in an organism has been demonstrated by the results of several coordination programs performed under the aegis of the IAEA [11, 21]. The content of microelements in hair reflects their concentration in an organism and serves as an integrated parameter of the mineral exchange, whereas the content of microelements in blood reflects variations in the elemental status significant with respect to the deviation level, short-time with respect to the exposition [27].

In addition, the use of hair for such investigation has a number of advantages: sampling is not connected with traumatisation and excludes the hazard of infectious diseases; samples are readily stored without time-limiting. Among the advantages of hair as a biochemical indicator, one should note the combination of excretory and accumulating functions in hair, which allows performing the retrospective analysis and forecasting the microelemental balance depending on time. The minerals those have once included in the structure of hair are not in the equilibrium with the rest of an organism any more.

This fact is important when a human is exposed to a short-term action of high concentration of metals. However, it should be noted that the concentration of minerals in hair does not reflect the state of an organism precisely at the moment of sampling. The analysis of the content of microelements in hair of healthy people demonstrates that the level of microelemental concentration varies depending on sex, place of residence, nationality. The environment exerts a considerable effect upon the concentration of separate elements in human hair.

In order to study elemental composition of Chukchi and Yakut people hair we have selected samples simultaneously with blood sampling from the same men and women. The potentialities of technique for determining the concentration of elements in hair with the use of SR XFA have allowed us to determine simultaneously much more elements than it is for blood.

TABLE 3

Elemental hair composition for Chukchi and Yakut people, μg/g

Element	Chukchi people				Yakut people			
	Men		Women		Men		Women	
	$<x_i>$ (σ_{gi})	n_i	$<x_i>$ (σ_{gi})	n_i	$<x_i>$ (σ_{gi})	n_i	$<x_i>$ (σ_{gi})	n_i
Ca	1120 (1.5)	29	1790 (1.7)	31	620 (1.7)	20	1610 (1.5)	20
Ti	7.0 (1.8)	24	5.8 (2.0)	18	n/d		n/d	
Cr	2.0 (1.6)	20	2.0 (1.8).	18	n/d		n/d	
Mn	10 (2.3)	29	24 (2.9)	31	2.4 (2.3)	8	4.3 (2.5)	10
Fe	77 (1.7)	29	78 (1.9)	31	46 (1.9)	20	53 (1.4)	20
Co	1.2 (1.6)	29	1.3 (2.0)	31	0.8 (1.9)	15	0.5 (1.9)	8
Ni	1.0 (1.5)	29	2.0 (2.1)	31	0.6 (1.6)	19	1.4 (1.9)	18
Cu	16 (1.3)	29	18 (1.6)	31	15 (1.2)	20	16 (1.2)	19
Zn	198 (1.2)	29	224 (1.4)	31	228 (1.2)	20	203 (1.3)	19
Ga	0.8 (2.7)	29	1.8 (1.5)	31	0.7 (1.4)	20	0.7 (1.3)	20
Ge	n/d		0.15 (2.0)	6	n/d		0.15 (1.4)	6
As	n/d		n/d		n/d		0.5 (1.8)	6
Se	0.5 (1.5)	29	0.3 (1.8)	28	0.6 (1.4)	20	0.35 (1.4)	17
Br	8.0 (2.6)	29	5.3 (1.9)	31	14.5 (1.7)	20	8.1 (2.4)	19
Rb	0.7 (3.0)	27	0.3 (3.5)	27	0.5 (1.7)	20	0.3 (2.0)	12
Sr	2.5 (2.1)	29	5.1 (2.6)	31	1.9 (1.8)	20	2.3 (2.5)	19
Y	0.2 (1.3)	10	n/d		0.05 (1.8)	9	0.25(1.3)	17
Zr	0.2 (1.8)	29	0.15 (2.5)	31	0.06 (1.9)	16	0.1 (1.6)	8
Nb	0.07 (3.5)	11	0.05 (1.4)	16	0.04 (2.3)	4	0.07 (1.2)	4
Hg	1.6 (2.4)	28	1.1 (2.4)	31	0.3 (2.0)	18	0.2 (1.5)	11
Pb	5.7 (3.4)	26	2.9 (3.4)	31	3.5 (1.7)	20	4.3 (2.1)	17
Bi	0.2 (2.1)	6	0.3 (3.0)	14	0.2 (1.5)	20	0.2 (1.8)	14

Note. For design. see Table 1.

Employing the SR XFA for the samples of Chukchi and Yakut people hair we have determined such elements as Ca, Ti, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Y, Zr, Hg, Pb, Bi. The results of the analysis are presented in Table 3. One can see that the concentration of elements is higher than the detection limit. Individual, sexual and regional differences in the content of the elements in hair of the populations under investigation have been revealed. So, there is no Ti and Cr found out in hair of Yakut people, there is no As in Chukchi and Yakut men revealed, whereas Ge was not observed in Chukchi and Yakut men, and Y was not registered in Chukchi women hair.

Comparison of elemental composition for Chukchi and Yakut people hair. Significant differences between men and women have been revealed in the elemental composition of Chukchi people for Ca, Mn, Ni, Ga, Se, Rb, Sr. For Chukchi women hair the concentration of Ca, Mn, Ni, Ga, Sr is higher, whereas that of Se and Rb is lower in comparison with men.

The comparative analysis of elemental content in Yakut men and women hair with the use of *t*-criterion has revealed a significant difference for the five elements such as Ca, Ni, Se, Br, Y. The concentration of Ca, Ni and Y is higher in the samples of women's hair, whereas the concentration of Se and Br is higher in the samples of men's hair.

The comparative analysis of elemental composition for hair of Yakut and Chukchi men and women has demonstrated that the concentration of such elements as Mn, Fe, Co and Hg is significantly different for all the men's

and women's populations under investigation. For elements Ca, Ni, Zn, Br and Zr, the difference in concentration is observed only for Chukchi and Yakut men, whereas for Ga and Sr such difference is observed for female population. The concentration of Ca, Mn, Fe, Co, Ni, Ga, Sr, Zr, Hg is higher in the samples of Chukchi men and women hair. The content of Zn, Br is higher only for Yakut men.

Features of elemental distribution in Yakut and Chukchi people hair. The data obtained concerning the elemental composition of Chukchi and Yakut people hair as a whole indicate a good supply level of populations under investigation with such vitally important element as Zn. This element being bound with enzymes, hormones and vitamins exerts a significant influence upon many vital processes: hematosis, reproduction, growth and development of an organism, the exchange of carbohydrates, proteins and fats [29]. One of the most important factors determining the content of Zn in hair consists in nutrition [30, 31], environmental quality and the economic status of populations. As compared to other elements of the concentration Zn in hair exhibits a low variability within and between Chukchi and Yakut people groups under investigation. Hair are considered to be a tissue reflecting the exchange of this element within an organism [27, 30–32]. The concentration of Zn in Chukchi and Yakut people hair corresponds to the ceiling of the range of values inherent in different regions [2, 5, 8].

The data obtained indicate both a relative stability and pronounced similarity of Cu concentration for different groups. The content of this element in Yakut and Chukchi people hair corresponds to the average values presented in the literature [2, 4, 32, 33].

The level of Fe concentration in hair for men and women groups under analysis is different. So, Fe content in Chukchi people hair is higher than in Yakut people hair. To all appearance, this fact depends on geochemical and other local factors. The values we have obtained are corresponding to the literature data [4, 5, 33]. To use the data concerning the content of Fe in hair for revealing iron-deficiency conditions, unfortunately, is impossible, since till now it is not known, whether could hair reflect the accumulation of Fe in an organism or the value of Fe supply [33].

The concentration of Co, another essential element, exhibits a rather high variability. Almost no sexual differences were revealed concerning the content of this element in hair for each group under investigation. The concentration of Co is higher in Chukchi men and women. The content of Se in hair for female Chukchi and Yakut people is much lower than for men of both populations, being at the same time comparable with the data for some groups of the population of Russia [34] where abnormal Se supply does not occur. The average concentration of Se in men's hair of both populations (0.5–0.6 μg/g) corresponds to a considerable content of this element in an organism.

Last time, an important significance is attached to selenium, since this chemical element belongs to irreplaceable microelements for humans, whereas its unbalanced supply could cause pathological phenomena [35, 36]. In papers [32, 33] data are cited concerning the presence of increased Se concentration in hair of some people groups living in Yakutia (2.08 μg/g) and Chukotka (1.3 μg/g). To all appearance, it could be connected with the investigation of hair belonging to the inhabitants of coastal areas who traditionally use for food various sea products enriched with Se. Our data are inherent in people living in continental areas with the normal Se content in the objects of the environment.

The average content of Hg, a toxic element with respect to its influence on an organism, in Chukchi men and women hair appeared to be higher in comparison with Yakut people. The presence of the increased concentration of this element is in a good agreement with the data presented in [32, 33]. The determination of this element in hair is often used in the studies on environmental contamination by mercury [36, 37]. Under natural conditions, the excess of Hg in an organism could be connected with using for food a lot of fish and other sea products. Really, we have obtained data indicating a supernormal content of this element in the humpback salmon, caught from the Kanchalan River, the source of potable water for locals.

The comparative analysis of our data concerning the concentration of Pb in Chukchi and Yakut people hair with the parameters recom-

TABLE 4

Results of the factor analysis for elemental blood composition for Chukchi and Eskimo people and the inhabitants of the Novosibirsk (reference group)

Parameters	Factors				
	1	2	3	4	5
		Chukchi women			
Elements	K, Fe, Rb	Ca, Cu, Zn	Sr	−Br	Ge
Loading	0.23	0.19	0.12	0.11	0.11
		Chukchi men			
Elements	K, Fe, Br, Rb	Ca, −Se, Sr	Ge, Pb	Cu	
Loading	0.25	0.17	0.15	0.14	
		Eskimo women			
Elements	K, Fe, Rb, Pb	Ca, Cu, Zn, Se	Br, −Sr		
Loading	0.30	0.29	0.13		
		Eskimo men			
Elements	K, Ca, Fe, Br, Rb	Cu, Sr	−Se	−Pb	
Loading	0.36	0.23	0.16	0.13	
		Reference group, women			
Elements	K, Zn, -Br	Cu, −Rb, Sr	Ca, −Fe, Se	Cu, −Pb	
Loading	0.25	0.19	0.18	0.17	
		Reference group, men			
Elements	K, Fe, Zn, Br, Rb	Pb	−Ca, −Sr		
Loading	0.34	0.18	0.17		

TABLE 5

Results of the factor analysis for elemental hair composition for Chukchi and Yakut people

Parameters	Factors				
	1	2	3	4	5
		Chukchi women			
Elements	Ca, Sr	Br, Rb, Pb	Hg, Cu	Fe, Zn	
Loading	0.26	0.24	0.16	0.16	
		Chukchi men			
Elements	Br, Rb, Hg	Ca, Mn, Sr	Ni, −Pb	Zn, Se	Cu
Loading	0.21	0.20	0.15	0.12	0.11
		Yakut women			
Elements	Ni, Y,Hg, Bi	Cu, Br, Pb	Ca, Sr	Fe, −Se	
Loading	0.26	0.25	0.24	0.18	
		Yakut men			
Elements	Br, Sr, Zr, Bi	Ca, Co, Pb	Cu, −Se	Fe, −Ga	Rb, −Hg
Loading	0.25	0.23	0.15	0.14	0.14

mended for other areas has not revealed any critical or hazardous values for humans [28, 37]. At the same time, the average data concerning the Pb content in Chukchi men hair (5.7 μg/g) might correspond to "the anxiety level" which, according to the foreign researchers, amounts to 6 μg/g for hair of adult people [38]. Besides, the range of Pb concentration in Chukchi people hair appeared maximal one among all the elements under investigation. A high variability of Pb content in Chukchi people hair, to all appearance indicates a genetic variety of the

population concerning the threshold sensitivity with respect to the element under consideration [33, 39].

The analysis of hair is the most extensively employed in Russia, CIS countries and Europe for the estimation of Pb influence upon humans, whereas in the USA investigators prefer to determine Pb content in blood as the most informative diagnostic biosubstrate with respect to this element in the opinion of American researchers, [37, 38].

We have performed the factor analysis of blood and hair elemental composition for Chukotka and Yakutia native inhabitants (see Tables 4, 5). It is seen that the factor analysis of all the set of blood and hair multielemental composition allows one to select from four to five factors for all the populations with different sex. In each separate case, they include in total from 9 to 10 elements for blood, from 9 to 13 elements for hair for everyone separate case. All the factors describe for blood from 78 to 88 %, for hair from 80 up to 93 % (factor loading) of total variability fraction for multielemental blood or hair composition in different groups.

From Table 4 it follows that for blood of Eskimo men and women, Chukchi men and reference group men, the most significant factor in this series of elements represents the first factor uniting the greatest number of elements (up to 4), and in this case K, Fe, Rb are common. The same elements are included into the first factor of blood for women. For Yakut men and women hair, the greatest number of elements also includes the first factor, though the common element is only Bi. The factor analysis of Chukchi men and women hair indicates two significant factors those include different chemical elements. As a whole, the data obtained indicate differences in the composition of the factors. This fact could be connected with a different level of mutual elemental influence upon the processes occurring in an organism dependent both on individual reactions with respect to environmental factors, national factors, and on the geochemical features of the environment.

CONCLUSIONS

For the whole blood of Chukchi and Eskimo women and men, we have simultaneously determined the concentration of K, Ca, Fe, Cu, Zn, Ge, Se, Br, Rb, Sr, Zr, Pb with use of SR XFA.

The technique potentialities of determining the concentration of chemical elements in the hair of some groups of Yakut and Chukchi men and women using XPA SR have allowed detecting simultaneously K, Ca, Ti, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Y, Zr, Mo, Hg, Pb, Bi.

Individual, sexual and regional differences in the concentration of elements in blood and hair of the populations under investigation have been established.

Elemental distribution features have been revealed in blood and hair for the North native inhabitants. There is Fe deficiency in Chukchi and Eskimo people observed for both men and women. It should be noted that the data concerning the average Se concentration in blood for Eskimo men and women indicate a good supplying the organism with this chemical element.

The factor analysis of multielemental blood and the hair composition has been performed for populations under investigation indicating that there are significant differences in the composition of the factors. To all appearance, this fact is connected with a different level of mutual elemental influence upon the processes occurring in an organism dependent both on ethnic, individual reactions, and on geochemical environmental factors. Thus, the material we have obtained allows us to estimate the elemental exchange level for some groups of Chukchi, Yakut, Eskimo people taking into account different biogeochemical environment.

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