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MACRO- AND TRACE ELEMENTS HAIR LEVELS IN EAST EUROPEAN POPULATION

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ABSTRACT: Hair elemental content of 20–40 y.o. people, living in countries of Eastern Europe (Russia, Croatia, Macedonia, Ukraine, Byelorussia, Lithuania, Latvia) was examined. Differences between hair concentration of essential and toxic elements in investigated populations was shown. It was established, that among women the highest load with toxic elements incidents to residents of Russia (Be, Cd, Pb, Sn, V), while among men — of Byelorussia (Cd, Pb, Sn) and Macedonia (As, Ni, Ti). The best provision with essential elements is characteristic of Latvian population (both men and women).

In the investigated regions the deficiencies of Mn, K, Na, Se, Fe Cr should be mentioned as typical women's hypoelementoses, while those of Mn, Fe, Se, K, Cr, Zn and Mg are typical for men. The most abundant hyperelementoses are excess of Ca, Mg, Cu, Si and Zn in women and Na, Si, Cu and K in men.

Introduction

The problem of insufficient provision of population with micronutrients, particularly trace elements, is extremely actual in Eastern Europe now. In the year 1999 a government decree "About measures for prophylaxis of the diseases connected with deficiency of iodine and other micronutrients" has been adopted in Russian Federation; since January 2004 a decree about abolition of iron deficiency will be accepted. At the same time, there are no enough data, adequately reflecting abundance and distribution of essential elements deficiency in population of East European countries including Russia. Recently we studied elemental status of children and adults living in Moscow Region (see Demidov, Skalny, 2001, 2002). Good applicability of multielement hair analysis for mass investigations, aimed to determination of provision of the population with essential minerals on the one hand and its load with toxic chemical elements on the other hand, has been demonstrated. Studies of A. Skalny (2002, 2003) allowed to suggest norms of concentration of some chemical elements in human hair for Russian Federation. In the present study we applied the suggested norms to estimation of elemental homeostasis in inhabitants of some East European countries, namely Russia, Ukraine, Byelorussia, Lithuania, Latvia, Macedonia (formerly Yugoslavian republic Macedonia) and Croatia.

Material and methods

Totally, 8487 relatively healthy peoples 20–40 y.o., living in different countries of Eastern Europe (see table 1) were observed and their hair samples, collected during 1997–2003, were investigated.

Sampling. Hair samples were taken from 3–5 places of scalp occipital zone. Proximal parts of hair strands 3–4 cm long were used for analysis. Hair (0.2–0.5 g) thus cut was immediately placed in special bags, which were then accurately sealed and labeled with a group number, the subject name, and the date.

All specimens were stored in dry, cool and ventilated environment until delivery to the laboratory and then kept in desiccators until analysis.

Sample treatment. Hair samples were cut in pieces no longer than 1 cm, processed by acetone (ex.p.) in 10–15 minutes, and then washed thrice by double distilled water. After that they were dried at 60°C till air-dry condition (Caroli et al., 1992). Then 0.1 g of the dried hair was used for analysis. Hair digestion has been carried out in plastic test-tubes by wet ashing with nitric acid on a balneum within 1 hour (Skalny et al., 2001).

Table 1. Distribution of the investigated persons according to sex and place of residence.

Country	Female	Male
Russia	2865	2756
Ukraine	635	308
Byelorussia	194	58
Latvia	87	30
Lithuania	392	177
Macedonia	281	126
Croatia	456	122

Analytical determination has been carried out by atomic emission spectrometry with inductively coupled argon plasma (ICP-AES) method using ICAP-9000 (Thermo Jarrell Ash, USA) and Optima 2000 DV (Perkin Elmer, USA) spectrometers.

Hair analyses were carried out in accordance with IAEA recommendations and methodical guidelines of Ministry of Health of Russian Federation. For the check-up our laboratory data the certified reference material of human hair GBW09101, obtained from Shanghai Institute of Nuclear Research, was used.

Results and discussion

The results of the study shows that chemical element levels in hair of investigated persons considerably differ depending on region of residence. For some elements, e.g. K, Cu, Ca, Mg, the difference between minimum and maximum concentration may be two fold and more.

The most distinct peculiarities are characteristic of Russian, Latvian, Lithuanian and Croatian women, and Latvian, Lithuanian and Macedonian men.

Russia

Generally, women living in Russian Federation are characterized by maximum concentration of such toxic chemical elements as Be (0.02±0,001 mg/kg), Cd (0.19±0.01 mg/kg), Pb (1.28±0.12 mg/kg), Sn (1.71± 0.03 mg/kg) and V (0.19±0.01 mg/kg). At the same time, hair level of some essential chemical elements, e.g. Cu (11.11±0.15 mg/kg), Fe (20.15±0.32 mg/kg) and Si (22±1 mg/kg), is considerably lower in comparison with the other countries. Among the investigated East European countries, Russia is characterized by significantly lowest concentration of Ca (1109±18 mg/kg) and Mg (98±2 mg/kg), as well as that of Na (217±7) with the exception of Latvia where Na level is also extremely low.

In Russian men the maximum average concentration of Al (22.86±0.3 mg/kg) and the minimal one of Mg (61±1 mg/kg) is detected.

Ukraine

In women living in Ukraine mean values of chemical element concentrations is found to be at level average for Europe, except P (207±8 mg/kg), which concentration is maximal, and Zn (173±2 mg/kg), which concentration is minimal.

Ukrainian men are characterized by the highest concentration of Ca (949±41 mg/kg), K (345±26 mg/kg) and V (0.18±0.03 mg/kg) in hair on the background of relatively low concentration of such toxic chemical elements as As (0.29±0.03 mg/kg) and Be (0.002±0.001 mg/kg).

Byelorussia

Both women and men living in Byelorussia are characterized by low concentration of Co in hair (0.09±0.01 mg/kg). In comparison with the other countries of Eastern Europe, the minimal level of Se (1.09±0.09 mg/kg) and Li (0.03±0.001 mg/kg) was detected in women. Maximum mean concentration of Cd (0.31±0.12 mg/kg), Pb (5.82±3.47 mg/kg) and Sn (1.48±0.51 mg/kg) on the background of minimum concentration of Fe (24.31±2.39 mg/kg), V (0.09±0.02 mg/kg) and Al (19.57±2.5 mg/kg) was found in hair of men.

Latvia

Latvian population differs from other investigated countries by the highest concentration of Cu (22.73±3.06 and 19.22±3.84 mg/kg), Mn (1.79±0.17 and 1.56±0.45 mg/kg) and Si (47±7 and 46±10 mg/kg) in hair (women and men, respectively). Latvian women are also characterized by the highest level of As (0.38± 0.07 mg/kg), Fe (29.38±3.14 mg/kg), Mg (210±20 mg/kg) and Zn (220±17) on the background of minimal level of P (153±4 mg/kg), Na (215±33 mg/kg) and V (0.09±0.01 mg/kg). Male part of the population is also featured by minimal mean concentration of Co (0.09±0.02 mg/kg), Ni (0.45±0.06 mg/kg), Se (1.21± 0.22), Sn (0.62±0.16 mg/kg) and Zn (160±7 mg/kg) in hair.

Lithuania

Generally, Lithuania differs from the other countries of Eastern Europe by lower mean concentration of virtually all elements in hair of population. In Lithuanian women the lowest level of toxic elements such as Be (0.002±0.001 mg/kg), Cd (0.09±0.01 mg/kg), Ni (0.45±0.02 mg/kg) and Pb (0.57±0.04 mg/kg), and essential ones such as Cr (0.63±0.03 mg/kg) and K (84±6 mg/kg) is detected. Lithuanian men are characterized by significantly lower concentration of Pb (1.28±0.17 mg/kg), relatively low level of Cd (0.12± 0.01 mg/kg), Ca (708±33 mg/kg), Cr (0.8±0.04 mg/kg), K (218±33 mg/kg), Na (365±36 mg/kg), P (169±3 mg/kg), and increased level of Zn (188±3 mg/kg).

Macedonia

Macedonian population is featured by considerable difference between males and females in intake of both toxic and essential chemical elements. Hair elemental content of Macedonian women almost do not differ from that of other East European countries (high levels of Ni and Ti; low levels of As and Sn, see Table 2). At the same time, hair of men is found to contain maximum mean concentration of 7 elements: As (0.52±0.26 mg/kg), Co (0.2±0.02 mg/kg), Fe (32.5±2.94 mg/kg), Ni (1.23±0.26 mg/kg), P (233±11 mg/kg), Se (2.22± 0.83 mg/kg), Ti (1.18±0.24 mg/kg), and the minimum one of Si (23±2 mg/kg).

Croatia

It is noticeable that both Croatian women and men have the highest hair level of Be (0.02±0,01 and 0.02±0.01 mg/kg) and Na (506±31 and 674±78 mg/kg) on the background of the lowest level of Mn (0.68±0.05 and 0.67±0.09 mg/kg) (females and males, respectively). Women are also characterized by the highest mean concentration of Ca (1877±68 mg/kg) and K (285±46 mg/kg), while men — by the highest mean concentra-

Table 2. Average concentrations of chemical elements in scalp hair of 20–40 y.o. people, living in different countries of Eastern Europe.

Element	Russia	Ukraine	Byelorussia	Latvia	Lithuania	Macedonia	Croatia
	females						
	n = 2865	n = 635	n = 194	n = 87	n = 392	n = 281	n = 456
Al	**22.14±0.27**	19.09±0.57	16.51±1.14	19.54±2.15	*14.4±0.79*	17.2±1.11	17.13±0.85
As	0.24±0.03	0.29±0.01	0.27±0.03	**0.38±0.07**	0.36±0.02	*0.19±0.02*	0.31±0.02
Be	**0.02±0.001**	0.003±0.001	0.01±0.001	0.01±0.001	*0.002±0.001*	0.004±0.001	**0.02±0.01**
Ca	*1109±18**	1539±47	1385±70	1847±147	1635±59	1520±77	**1877±68**
Cd	**0.19±0.01**	0.17±0.04	0.14±0.05	0.1±0.01	*0.09±0.01*	0.1±0.01	0.12±0.01
Co	**0.24±0.01***	0.15±0.01	*0.09±0.01*	0.18±0.04	0.12±0.01	0.16±0.01	0.16±0.01
Cr	**0.96±0.02**	0.88±0.13	0.68±0.07	0.7±0.06	*0.63±0.03*	0.73±0.03	0.87±0.06
Cu	*11.11±0.15*	12.81±0.37	16.81±0.81	**22.73±3.06***	16.37±0.82	12.33±0.67	12.53±0.29
Fe	*20.15±0.32*	25.06±5.74	20.79±1.57	**29.38±3.14**	22.12±1.51	22.82±1.8	21.12±0.97
K	128±5	208±13	136±22	168±33	*84±6**	140±16	**285±46***
Li	0.09±0	0.06±0.01	*0.03±0.001*	0.05±0.01	0.09±0.04	0.06±0.01	**0.13±0.06**
Mg	*98±2**	130±5	117±8	**210±20**	151±8	124±8	181±8
Mn	1.28±0.04	1.11±0.08	1.24±0.12	**1.79±0.17**	1.74±0.15	1.1±0.17	*0.68±0.05**
Na	217±7*	427±22	313±46	*215±33**	243±26	271±24	**506±31***
Ni	0.54±0.02	0.79±0.08	0.54±0.05	0.62±0.07	*0.45±0.02*	**1.1±0.22**	0.69±0.05
P	170±1	**207±8***	169±4	*153±4*	161±2	183±5	180±4
Pb	**1.28±0.12**	0.98±0.06	0.82±0.11	1.19±0.31	*0.57±0.04**	1.07±0.14	1.09±0.09
Se	**1.7±0.03**	1.59±0.12	*1.03±0.09*	1.53±0.24	1.3±0.08	1.1±0.09	1.11±0.05
Si	*22±1*	29±1	28±3	**47±7**	40±3	26±2	29±2
Sn	**1.71±0.03**	1.06±0.05	0.88±0.1	1.54±0.35	0.96±0.05	*0.87±0.06*	0.92±0.04
Ti	*0.56±0.02*	0.63±0.03	0.77±0.06	0.88±0.11	0.73±0.05	**1.08±0.12**	0.78±0.1
V	**0.19±0.01**	0.18±0.03	0.14±0.05	*0.09±0.01*	0.11±0.01	0.1±0.01	0.13±0.01
Zn	198±1	*173±2*	194±4	**220±17**	216±3	210±5	184±3
Elements	males						
	n = 2756	n = 308	n = 58	n = 30	n = 177	n = 126	n = 122
Al	**22.86±0.3**	20.79±1.02	*19.57±2.5*	21.77±3.51	21.31±1.9	22.62±1.36	21.35±1.51
As	0.31±0.01	*0.29±0.03*	0.3±0.06	**0.52±0.2**	0.3±0.03	**0.52±0.26**	0.37±0.05
Be	0.01±0.001	*0.002±0.001*	0.004±0.001	0.004±0.001	0.003±0.001	0.01±0	**0.02±0.01**
Ca	807±11	**949±41**	745±79	845±133	*708±33*	905±63	808±53
Cd	0.23±0.01	0.28±0.07	**0.31±0.12**	0.21±0.06	*0.12±0.01*	0.22±0.04	0.14±0.01
Co	0.19±0.01	0.12±0.01	*0.09±0.01*	*0.09±0.02*	0.11±0.01	**0.2±0.02**	0.13±0.01
Cr	0.97±0.02	0.87±0.05	0.99±0.17	**1±0.23**	*0.8±0.04*	0.82±0.04	0.93±0.09
Cu	12.99±0.17	13.29±0.45	13.38±0.86	**19.22±3.84**	14.82±1	11.57±1.09	*11.5±1.05*
Fe	25.26±0.45	25.89±1.39	*24.31±2.39*	28.3±5.83	30.22±2.8	**32.5±2.94**	25.97±2.34
K	289±7	**345±26**	302±51	278±54	*218±33**	328±38	327±39
Li	0.09±0	0.08±0.02	0.08±0.05	**0.25±0.17**	*0.06±0.01*	0.09±0.04	0.08±0.01
Mg	*61±1*	92±5	75±10	96±20	66±5	73±5	**97±10**
Mn	0.92±0.03	1.08±0.13	0.93±0.13	**1.56±0.45**	1.03±0.1	0.96±0.1	*0.67±0.09**
Na	508±11	629±44	645±119	516±83	*365±36**	571±60	**674±78**
Ni	0.61±0.02	0.77±0.08	0.76±0.17	*0.45±0.06*	0.52±0.05	**1.23±0.26**	0.74±0.1
P	177±1	189±4	183±12	192±20	*169±3*	**233±11***	190±8
Pb	1.7±0.06	3.01±0.67	**5.82±3.47**	2.2±0.69	*1.28±0.17**	2.21±0.3	1.49±0.15
Se	1.46±0.03	1.29±0.1	1.58±0.39	*1.21±0.22*	1.28±0.09	**2.22±0.83**	1.47±0.23
Si	27±1	29±2	35±6	**46±10**	35±3	*23±2*	29±3
Sn	1.26±0.02	0.98±0.09	**1.48±0.51**	*0.62±0.16**	0.97±0.1	0.98±0.08	1.08±0.09
Ti	*0.51±0.01**	0.63±0.04	0.73±0.11	0.99±0.23	0.9±0.1	**1.18±0.24**	0.63±0.05
V	0.17±0.01	**0.18±0.03**	*0.09±0.02*	0.12±0.03	0.11±0.01	0.14±0.01	0.15±0.02
Zn	180±1	163±3	179±7	*160±7*	**188±3**	180±6	169±6

Bold font — highest concentration, Italic font — lowest concentration; * — concentration is significantly higher (lower), then in all other countries.

tion of Mg (97±10 mg/kg), as compared with population of other East European countries.

Thus, it is may be concluded that among females the highest load with toxic chemical elements is characteristic of Russian women (Be, Cd, Pb, Sn, V), while among males — Byelorussian (Cd, Pb, Sn) and Macedonian men (As, Ni, Ti). Provision of population with essential chemical elements is the best in Latvia (both women and men).

Recently (Skalny, 2002, 2003) we suggested limits of physiological (normal) range of chemical element concentrations in human hair, which were calculated on the basis of percentile scaling. We suppose it would be interesting to compare the concentrations of chemical elements in hair found in the present study with the norms (see Table 2), and thus calculate occurrence of decreased and increased concentrations in residents of the investigated regions of Eastern Europe.

As it may be seen in Table 4, the elements, which low level may be considered as a risk factor of hypoelementisis development in all investigated regions, are Mn, K, Na, Se, Fe and Cr for female part of population and Mn, Fe, Se, K, Cr, Zn and Mg for the male part (occurrence of decreased concentration more than 35%). Also, low concentration of sodium in hair of women is rather usual. The countries where population is characterized by the most distinct hypoelementoses in women are Byelorussia, Russia and Macedonia, in men — Byelorussia, Russia, Macedonia and Croatia. The most trouble-free countries, according to this parameter, are Croatia (women) and Lithuania (men).

Table 3. The conditional biologically allowable hair elements levels (ppm).

Element	Male		Female	
	Lower limit	Upper limit	Lower limit	Upper limit
Al	2	30	2	45
As	0	2	0	2
Be	0	1	0	1
Ca	340	720	600	1830
Cd	0	0.5	0	0.5
Co	0.02	1	0.02	1
Cr	0.3	0.8	0.25	0.6
Cu	10	15	10	20
Fe	10	20	10	20
K	30	170	20	100
Li	0	0.5	0	0.5
Mg	30	65	55	170
Mn	0.25	1	0.3	1
Na	60	310	40	160
Ni	0	2	0	2
P	140	180	130	170
Pb	0	5	0	5
Se	0.3	1.5	0.2	1.5
Si	10	35	15	50
Sn	0	3	0	3
Ti	0	3	0	3
V	0	0.5	0	0.5
Zn	160	210	180	230

According to the data obtained, the elements, which increased level is the most abundant in population, are Ca, Mg, Cu, Si and Zn for females, and Na, Si, Cu, K for males (occurrence of increased concentration of these elements in hair is more than 15%). High level of chemical elements in hair of women is more characteristic for Ukraine (Ca, Mg, Cu, K, Na, P and Si), Croatia (Ca, Mg, Cu, K, Na and Si), and Latvia (Ca, Cu, Mg, Mn, Si, Zn), while for men it is Ukraine (Al, Cr, Cu, K, Mg, Na, P, Si) only.

It is notable that parameters of elements metabolism in female and male population have some particular differences. Thus, males are featured by decreased concentration of hair Zn and Mg while females are mostly characterized by high content of these elements in hair. High occurrence of increased Ca, Mg concentration, observed in women of all investigated regions, is not characteristic of men, but excess of Al, K, Na in hair, usual for men, is considerably more rare in women.

Increased occurrence of excess accumulation of toxic elements such as Pb, Cd and As in hair is characteristic of women in Russia, Ukraine and Latvia and men of Russia, Byelorussia, Ukraine and Latvia. Male part of the population in these countries is found to be more susceptible to influence of toxicants than the female one. The maximum occurrence of increased As concentration in hair of females was detected as 9.2% (Latvia) vs. 13.3% in males (Latvia). Analogous data for Pb was 4.6% (females, Latvia) and 12,9% (males, Ukraine); for Cd — 3.49% (females, Ukraine) and 13,3% (males, Latvia). Increased concentration of Ni in hair is also observed often enough (up to 7,8% in females and up to 9,5% in males).

Conclusion

1. There are significant differences in provision of population with essential chemical elements between different countries of Eastern Europe.

2. Among females the highest rate of toxic elements load is characteristic of Russian women (Be, Cd, Pb, Sn, V), while among males — Byelorussian (Cd, Pb, Sn) and Macedonian (As, Ni, Ti) men.

3. The highest level of provision with essential chemical elements is found in Latvian population (both males and females).

4. In the observed countries, deficiencies of Mn, K, Na, Se, Fe and Cr in women and those of Mn, Fe, Se, K, Cr, Zn and Mg in men may be considered as the most characteristic hypoelementoses.

Table 4. Frequency (%) of hyper- and hypoelementoses in countries of Eastern Europe.

Element	females						males					
	Byelorussia		Ukraine		Lithuania		Byelorussia		Ukraine		Lithuania	
	increased	decreased	increased	decreased	increased	decreased	increased	decreased	increased	decreased	increased	decreased
Al	4.15%	8.29%	5.21%	1.90%	2.81%	7.40%	17.24%	3.45%	15.26%	1.62%	16.38%	4.52%
As	4.15%	0.00%	4.42%	0.00%	4.59%	0.00%	8.62%	0.00%	3.90%	0.00%	3.39%	0.00%
Be	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Ca	20.21%	4.15%	26.07%	2.05%	29.59%	1.79%	6.90%	5.17%	12.34%	3.57%	6.21%	7.34%
Cd	2.07%	0.00%	3.49%	0.00%	0.51%	0.00%	10.34%	0.00%	10.42%	0.00%	3.39%	0.00%
Co	0.00%	22.28%	0.79%	7.59%	0.51%	10.97%	0.00%	18.97%	0.32%	13.64%	0.00%	15.82%
Cr	7.33%	39.27%	10.95%	39.68%	6.12%	39.80%	15.52%	32.76%	14.71%	27.12%	16.38%	32.77%
Cu	33.16%	2.07%	15.48%	6.16%	23.47%	3.57%	37.93%	5.17%	21.10%	3.90%	22.60%	1.69%
Fe	6.22%	44.56%	4.11%	39.49%	8.16%	43.62%	5.17%	44.83%	7.47%	40.58%	11.30%	41.81%
K	6.22%	55.96%	15.64%	35.86%	3.06%	57.91%	24.14%	29.31%	29.22%	19.48%	13.56%	41.24%
Li	0.00%	0.00%	0.47%	0.00%	0.26%	0.00%	1.72%	0.00%	0.32%	0.00%	0.57%	0.00%
Mg	20.21%	10.36%	23.54%	12.16%	27.04%	4.34%	5.17%	20.69%	16.56%	12.34%	3.95%	14.12%
Mn	8.29%	40.41%	5.53%	46.13%	14.03%	38.27%	1.72%	44.83%	3.90%	40.26%	3.39%	41.24%
Na	11.40%	31.09%	27.49%	12.48%	8.93%	24.23%	31.03%	13.79%	38.31%	5.52%	20.34%	18.08%
Ni	4.66%	0.00%	6.48%	0.00%	1.79%	0.00%	6.90%	0.00%	6.17%	0.00%	2.82%	0.00%
P	6.22%	11.40%	20.38%	8.53%	6.12%	9.69%	5.17%	13.79%	20.45%	3.90%	6.78%	6.21%
Pb	1.04%	0.00%	2.38%	0.00%	0.77%	0.00%	12.07%	0.00%	12.99%	0.00%	4.52%	0.00%
Se	5.82%	57.14%	9.46%	38.30%	8.16%	46.17%	12.50%	39.29%	6.58%	42.43%	10.80%	48.86%
Si	24.87%	19.69%	26.22%	14.06%	32.91%	11.99%	27.59%	12.07%	26.95%	7.14%	32.20%	6.78%
Sn	6.62%	0.00%	5.03%	0.00%	3.44%	0.00%	10.00%	0.00%	3.65%	0.00%	2.60%	0.00%
Ti	3.11%	0.00%	4.27%	0.00%	6.12%	0.00%	3.45%	0.00%	3.57%	0.00%	6.21%	0.00%
V	3.31%	0.00%	5.31%	0.00%	1.90%	0.00%	2.50%	0.00%	5.19%	0.00%	0.66%	0.00%
Zn	8.81%	11.40%	6.16%	22.59%	21.68%	4.59%	1.72%	22.41%	1.30%	37.34%	2.26%	10.17%

Element	females						males					
	Latvia		Macedonia		Croatia		Latvia		Macedonia		Croatia	
	increased	decreased	increased	decreased	increased	decreased	increased	decreased	increased	decreased	increased	decreased
Al	9.20%	4.60%	5.69%	8.54%	3.07%	5.26%	13.33%	0.00%	8.73%	2.38%	17.21%	1.64%
As	9.20%	0.00%	1.42%	0.00%	3.07%	0.00%	13.33%	0.00%	2.38%	0.00%	3.28%	0.00%
Be	0.00%	0.00%	0.00%	0.00%	0.22%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Ca	35.63%	3.45%	24.20%	6.05%	37.28%	2.41%	10.00%	6.67%	6.35%	11.90%	5.74%	6.56%
Cd	3.45%	0.00%	1.78%	0.00%	3.29%	0.00%	13.33%	0.00%	7.14%	0.00%	4.10%	0.00%
Co	1.15%	8.05%	0.36%	14.59%	0.88%	3.95%	0.00%	6.90%	0.79%	6.35%	0.00%	6.56%
Cr	12.64%	32.18%	9.61%	38.79%	11.84%	26.75%	30.00%	26.67%	12.70%	31.75%	17.21%	28.69%
Cu	45.98%	4.60%	14.23%	10.32%	17.76%	8.33%	36.67%	3.33%	17.46%	10.32%	14.75%	15.57%
Fe	13.79%	26.44%	4.27%	39.15%	4.61%	39.47%	6.67%	40.00%	7.14%	38.89%	5.74%	43.44%
K	11.49%	51.72%	6.05%	46.98%	19.08%	29.61%	20.00%	16.67%	17.46%	18.25%	24.59%	21.31%
Li	1.15%	0.00%	2.14%	0.00%	0.88%	0.00%	3.33%	0.00%	1.59%	0.00%	0.82%	0.00%
Mg	48.28%	3.45%	21.00%	11.39%	38.82%	9.43%	13.33%	16.67%	4.76%	24.60%	13.93%	21.31%
Mn	21.84%	25.29%	4.98%	63.70%	1.97%	63.16%	3.33%	33.33%	3.17%	51.59%	1.64%	61.48%
Na	8.05%	33.33%	12.46%	21.35%	32.24%	10.31%	36.67%	10.00%	26.98%	9.52%	39.34%	7.38%
Ni	6.90%	0.00%	7.83%	0.00%	3.29%	0.00%	0.00%	0.00%	9.52%	0.00%	5.74%	0.00%
P	3.45%	17.24%	6.05%	12.10%	8.99%	8.99%	3.33%	13.33%	6.35%	2.38%	8.20%	13.11%
Pb	4.60%	0.00%	2.49%	0.00%	2.19%	0.00%	10.00%	0.00%	5.56%	0.00%	6.56%	0.00%
Se	13.79%	54.02%	7.22%	50.18%	5.26%	47.81%	6.67%	36.67%	9.60%	40.80%	9.84%	45.08%
Si	35.63%	12.64%	19.93%	25.27%	21.05%	14.47%	33.33%	10.00%	15.08%	20.63%	22.95%	9.02%
Sn	13.11%	0.00%	4.63%	0.00%	5.44%	0.00%	4.17%	0.00%	7.63%	0.00%	10.53%	0.00%
Ti	9.20%	0.00%	9.25%	0.00%	3.95%	0.00%	10.34%	0.00%	8.73%	0.00%	4.10%	0.00%
V	0.00%	0.00%	0.77%	0.00%	2.31%	0.00%	4.17%	0.00%	3.39%	0.00%	6.25%	0.00%
Zn	18.39%	12.64%	20.36%	15.00%	10.75%	16.89%	0.00%	26.67%	4.76%	34.13%	2.46%	29.51%

Table 4 (continuing).

Element	Russia, females		Russia, males	
	increased	decreased	increased	decreased
Al	6.79%	2.33%	17.53%	1.16%
As	4.13%	0.00%	3.81%	0.00%
Be	0.09%	0.00%	0.17%	0.00%
Ca	19.87%	7.01%	8.58%	9.52%
Cd	3.90%	0.00%	8.53%	0.00%
Co	0.92%	10.39%	1.17%	10.37%
Cr	11.71%	36.59%	17.14%	28.97%
Cu	21.32%	6.32%	21.86%	6.82%
Fe	6.20%	35.15%	7.12%	38.87%
K	7.05%	49.01%	20.04%	26.46%
Li	1.58%	0.00%	1.86%	0.00%
Mg	21.03%	16.81%	7.98%	24.72%
Mn	7.96%	42.72%	4.84%	47.16%
Na	12.17%	25.94%	28.95%	11.04%
Ni	4.60%	0.00%	4.78%	0.00%
P	9.59%	10.78%	9.51%	8.55%
Pb	3.17%	0.00%	8.45%	0.00%
Se	8.93%	39.87%	8.60%	41.04%
Si	27.20%	22.82%	21.34%	17.89%
Sn	14.91%	0.00%	12.29%	0.00%
Ti	4.96%	0.00%	3.96%	0.00%
V	3.54%	0.00%	4.00%	0.00%
Zn	13.47%	10.01%	4.29%	23.20%

5. Relatively increased element concentration in hair is most often detected for Ca, Mg, Cu, Si, Zn in females and Na, Si, Cu, K in males.

6. Risk of intoxication by toxic chemical elements is the highest in males of Latvia, Russia, Ukraine and Byelorussia.

7. The obtained data indicate necessity of differentiated approach to developing of projects aimed to improvement of population health using preparations of major and trace elements.

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