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MICROELEMENTS IN THE SOILS AND PLANTS OF THE TYUMEN FEDERAL NATURE RESERVE

SUMMARY. The research results of determining the microelement contents in the soils and plants of the Tyumen Federal Nature Reserve are presented. The contents of 8 labile microelements in the soils extracted by the ammonium acetate buffer solution (pH 4.8) as well as the contents of these elements in the plants determined by atomic absorption are analyzed. It is shown that the contents of most labile microelements in the soils of the Tyumen Federal Nature Reserve insignificantly vary, and the contents of labile Zn, Cu, Co, and Ni do not exceed maximum allowable concentrations. The contents of the microelements in the plants vary widely due to the species distinctions. The estimation of the percentage of the samples with excessive and insufficient concentrations of the microelements provides the sequences, which represent regularities of the microelement accumulation by the plants of the nature reserve. It is found that nickel concentrates in the plants of the Tyumen Federal Nature Reserve to the fullest extent, manganese and cadmium are the following; and at the same time, the plants lack iron and copper. It is shown that the ecological situation in the Tyumen Federal Nature Reserve is safe since the excess of maximum allowable concentrations of the labile microelements in the soils and plants is not registered. However, the insufficient concentrations of copper and iron in plants are in evidence, which can be eliminated by application of micronutrients containing these elements at the sites where forage grasses are grown for winter feeding of animals.

KEY WORDS. Microelement, specially protected area, baseline territory.

While conducting a biochemical research, it is of fundamental importance to select baseline territories of minimal anthropogenic impact and, consequently, of minimal soil and plant components pollution. Among the sites for the purpose of soil baseline monitoring are reserves and nature sanctuaries where soils are exposed to minimal anthropogenic pollution [1].

Specially protected areas can be used as a regional baseline to assess the contamination of soils and plants on other territories of the region under study.

Besides, specially protected areas are under studies conducted for the purpose of soil environmental monitoring [2].

The specially protected areas in the south of the Tyumen Region are represented by two federal nature reserves — the Tyumen and Belozyorsky ones. We chose these nature reserves as baseline territories for biogeochemical studies of microelements in the soil-plant system in the south of the Tyumen Region. The Tyumen Federal Nature Reserve is of interest for studying the formation of the surface water chemical composition in the baseline territories.

At first, the research was concerned with the soils and plants of the Tyumen Federal Nature Reserve. During the 2009-2010 summer seasons, the expeditions were arranged together with the scientists of the Institute of Soil Science and Agrochemistry, the Siberian Branch of the Russian Academy of Science to take the samples of soils and plants within the territory of the Tyumen Federal Nature Reserve.

The Tyumen Federal Nature Reserve is located in the Nizhnetavdinsky District of the Tyumen Region, in the south-western part of the West Siberian Lowland, within the Tarmansky lake-boggy area, in the interstream area of the middle course of the Tavda and Tura rivers.

The nature reserve was founded to protect animals inhabiting it in their strong relations with the environment, to maintain the species diversity, to assure the optimal reproduction level of protected animals, as well as to spread knowledge, the experience of environmental friendliness, and for the population to be aware of the environmental laws. Among the objects under protection, there are such species as *black stork, greater spotted eagle, golden eagle, white-tailed eagle, gyrfalcon, peregrine falcon, sea parrot,* and *eagle-owl.*

The nature reserve also provides the habitat for mammals, such as elk, wild boar, brown bear, and blue hare. The unique ecosystems are subject to protection — southernmost natural boundaries of the spruce forest with an admixture of cedar, lime trees, juniper and heather, as well as the Tarmanskaya water-lake system determining, to a great degree, the moisture index of this area and the water conditions of the streams and rivers flowing from it.

The area of the nature reserve is 53,585 ha.

The nature reserve borders agricultural lands, planning compartments of the state forest resource, and the inter-farm forestry enterprise; its border coincides with the administrative border of the Tyumen and Sverdlovsk Regions on the west.

The soil covering of the Tyumen Federal Nature Reserve is represented by light-gray forest soils.

To conduct the research, we set the following research objectives:

1. To determine the contents of macro- and microelements in the soils and plants of the nature reserve for obtaining baseline concentrations of these elements.

2. To determine the level of microelement concentrations in the soils and plants for the ecological situation assessment.

3. To assess the availability of microelements contained in the soils of the nature reserve for the plants.

We selected 9 samples of the surface soil layer (0-10cm) in the territory of the reserve and the samples of herbaceous plants.

The plant species composition is shown in List 1.

List 1

Plant species composition of the Tyumen Federal Nature Reserve

1) avens; 2) horsetail; 3) agrimony; 4) veronika; 5) plantain; 6) horsetail; 7) bromegrass; 8) rhaponticum; 9) wood blue grass; 10) lucerne; 11) gigantic bent grass; 12) timothy; 13) evening campion; 14) milfoil; 15) blue cornflower; 16) cinquefoil; 17) zvuchatka; 18) vetch; 19) meadow grass; 20) silvery cinquefoil; 21) bromegrass;

22) cowgrass; 23) bluet; 24) alsike clover; 25) dropwort; 26) bromegrass; 27) dead grass; 28) awnless brome; 29) dead grass; 30) clover; 31) dead grass; 32) dead grass.

Table 1 represents the plant species composition and the location of the soil sampling points.

Table 1

The location of the soil sampling points and plant species composition

Sample No.	Location	Plant species composition and sample No.
1	Border of forest	Horsetail — 2
		Hairy agrimony — 3
		Plantain — 5
		Awnless brome — 7
1	2	3
1	2	3
		Plantain — 23
		Dropwort — 25
		Clover — 30
2	Herbs, strawberry	Aleppo avens — 1
		Veronika — 4
		Milfoil — 14
		Golden cinquefoil — 16
4	Foalfoot	Rhaponticum
		Gigantic bent grass
		Timothy
		Plantain
		Silvery cinquefoil
		Alsike clover
5	Herbs	Bromegrass
		Dead grass
6	St.-John's wort	no
8	Lime tree	Lucerne
		Cowgrass
9	Common horsetail	
3	Herbs (dropping bromegrass)	Awnless brome
		Dead grass
7	Thistle (dropping bromegrass)	Bromegrass
		Dead grass
10	Awnless brome, ant colony	no
	Mixture from points 1 and 2	Wood horsetail
	Mixture from points 4 and 8	Wood bluegrass
	Mixture from points 4 and 5	Meadow grass
	Mixture from points 1,2,4 and 8	Dead grass

The contents of 14 labile macro- and microelements in the soils extracted by the ammonium acetate buffer solution (pH 4.8) were analysed in the laboratory of the Institute of Soil Science and Agrochemistry, the Siberian Branch of the Russian Academy of Science, using the *Kvant-2* atomic absorption spectrophotometer. The results are given in Table 2.

Table 2

The contents of labile macro- and microelements in the soils of the Tyumen Federal Nature Reserve (the extragent is an ammonium acetate buffer, pH is 4.8; the content of an microelement is expressed in mg/kg)

No.	Fe	Mn	Zn	Cu	Co	Ni	Pb	Cd
1	43.7	95	0.85	0.11	0.25	1.49	0.28	0.035
2	48.1	135	1.43	0.1	0.54	2.2	0.1	0.049
3	18.2	85	0.73	0.16	0.14	1.22	0.1	0.052
4	31.7	68.3	0.62	0.13	<0.005	1.15	0.12	0.026
5	13.9	136.7	1.72	0.11	0.23	1.58	0.13	0.061
6	21.5	65	0.9	0.11	0.18	1.33	0.13	0.037
7	31.2	215	2.69	0.15	0.36	3.03	0.73	0.19
M+m	13.9-48.1	65-215	0.62-2.69	0.1-0.16	<0.005-0.54	1.15-3.03	0.1-0.73	0.035-0.19
Average	29.7	114.3	1.28	0.12	0.24	1.71	0.23	0.040
MAC	-	-	23	3	5	4	6	-

Note: MACs are given by [1]; MACs for labile Fe, Mn, Cd have not been established in Russia.

The results presented in Table 2 demonstrate that the contents of most labile elements in the soils of the Tyumen Federal Nature Reserve insignificantly vary, and the contents of labile Zn, Cu, Co, and Ni do not exceed maximum allowable concentrations (MACs for labile Fe, Mn, Cd have not been established in Russia).

We determined the contents of macro- and microelements in the plants of the Tyumen Federal Nature Reserve, the results are presented in Table 3.

Table 3

Gross contents of chemical elements in the plants of the Tyumen Federal Nature Reserve

Plant	Contents of microelements (mg/kg)							
	Cd	Co	Cu	Fe	Mn	Ni	Pb	Zn
1 — Aleppo avens	0.112	0.71	0.89	4.6	5	0.24	0.11	10.13
2 — Horsetail	0.267	0.38	7.32	33.9	93	10.90	0.22	43.22
3 — Hairy agrimony	0.634	< 0.1	20.74	69.0	115	10.87	2.63	102.98
4 — Veronika	0.430	2.61	13.03	72.5	111	3.21	1.07	62.41
5 — Plantain	0.104	0.62	4.07	13.1	72	2.97	0.86	18.92
6 — Wood horsetail	0.441	0.66	1.97	9.0	19	1.84	0.34	19.10

The end of Table 1

7 — Awnless bromegrass	0.333	0.98	4.39	32.7	98	0.84	0.39	27.31
8 — Rhaponticum	0.256	1.13	5.85	18.2	45	7.79	0.56	26.01
9 — Wood bluegrass	0.682	3.91	11.46	90.2	285	6.55	1.82	69.75
10 — Lucerne	0.689	0.57	9.41	112.4	171	6.45	1.57	48.15
11 — Gigantic bent grass	0.198	< 0.1	9.41	55.1	571	5.45	0.79	82.82
12 — Timothy	1.315	< 0.1	10.95	64.9	2.231	5.67	2.77	45.30
14 — Milfoil	0.242	0.29	7.38	63.3	85	7.41	0.51	42.28
15 — Plantain	0.174	0.19	2.26	10.9	32	1.77	0.60	22.29
16 — Golden cinquefoil	0.610	< 0.1	5.52	45.0	192	4.95	2.29	62.48
19 — Bluegrass	0.467	< 0,1	11,45	78.0	333	5.40	1.46	32.81
20 — Silvery cinquefoil	0.480	< 0.1	14.82	101.1	437	16.63	1.07	113.31
21 — Bromegrass	0.877	< 0.1	11.95	86.1	289	1.78	1.63	95.91
22 — Cowgrass	0.300	0.27	12.09	44.3	119	10.30	0.85	27.98
23 — Plantain	0.137	< 0.1	3.56	13.6	25	4.62	0.38	16.53
24 — Alsike clover	0.338	1.33	11.92	113.1	132	12.89	0.82	32.12
25 — Dropwort	0.129	< 0.1	9.10	43.3	137	4.40	0.95	52.63
26 -Bromegrass	0.457	< 0.1	10.71	45.9	260	1.96	1.05	49.52
27 — Dead grass	0.317	0.46	5.12	31.1	160	1.58	1.19	19.51
28 — Awnlless bromegrass	0.311	1.79	16.47	312.6	489	3.22	1.94	86.68
29 — Dead grass	0.549	< 0.1	6.70	38.5	228	2.61	1.44	25.52
30 — Clover	0.054	< 0.1	6.31	12.5	80	4.76	0.34	14.47
31 — Dead grass	0.131	< 0.1	3.59	37.3	95	2.53	0.99	17.33
32 — Dead grass	0.157	0.85	4.46	44.9	128	1.41	0.73	21.32

From the data presented in Table 3, we can conclude that the contents of microelements in the plants vary widely, which depends on the species properties of the plants [3-4].

For example, the highest concentration of zinc was registered in silvery cinquefoil; the one of copper — in hairy agrimony; the one of iron — in awnless bromegrass; the one of manganese — in timothy; the one of cobalt — in wood bluegrass; the one of cadmium — in timothy; the one of nickel — in silvery cinquefoil; the one of lead — in timothy: 113.31; 20.71; 312.6; 2,231; 3.91; 1.315; 16.63; 2.77 mg/kg, respectively. Timothy is notable for its significant capacity to concentrate microelements, accumulating manganese, lead, and cadmium.

The comparison of the microelement contents in the plants of the Tyumen Federal Nature Reserve with conventional agrochemical and biochemical criteria indicators of these elements in rough and succulent feed (Table 4) allowed regularities of accumulating microelements by the plants to be identified in the territory of the nature reserve.

Table 4

Agrochemical and biochemical criteria of the contents of microelements in crops

Soils	Crops	Products	Fe	Mn	Zn	Cu	Co	Pb	Cd	Ni
MRL for food grain				-	50	10	-	0.5	0.1	1
MRL for feeder grain			100	-	50	30	-	5	0.3	1
MRL for rough and succulent feed			100	-	50	30	1	5	0.3	3
Agrochemical and biochemical content criteria	insufficient	plants	<40	<30	<20	<5	<0.2	-	-	
	standard	in the anthesis phase	40-100	30-100	21-60	5-20	0.21-1.0	-	-	
	(optimal)									
	excessive		>100	>100	>60	>20	>1.0	-	-	

Calculating the percentage of the samples with the excessive and insufficient concentrations of the microelements allowed the sequences reflecting regularities of the microelement accumulation by the plants of the nature reserve to be obtained.

For example, the microelements, by their excessive contents in the plants, are arranged in the following sequence (given in brackets is the number of the samples with an excessive content of an element in %): Ni (62.1) > Cd, Mn (58.6) > Zn (27.6) > Co (17.2) > Fe (13.8) > Cu (3.4).

The sequence obtained for the microelement insufficient contents is as follows: Fe (41.3) > Cu (27.5) > Zn (24.1) > Mn (10.3).

Thus, nickel concentrates in the plants of the Tyumen Federal Nature Reserve to the fullest extent, manganese and cadmium are the following; at the same time, the plants lack iron and copper. The number of the samples with an insufficient content of zinc at 24.1% corresponds to the number of the samples with an excessive content of this element — 27.1%.

On the basis of our research, it is possible to conclude that the ecological situation in the Tyumen Federal Nature Reserve is safe, since the excess of maximum allowable concentrations of the labile microelements in the soils and plants is not registered. However, the insufficient concentrations of copper and iron in the plants are in evidence, which can be eliminated by the application of micronutrients containing these elements at the sites where forage grasses are grown for winter feeding of animals.

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