Biogeochemical researches of trace elements content in vegetation of Tatarstan

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Abstract. The paper presents the review of the results of studies of trace elements contents in wild plants in the Middle Volga conditions (in the example of the Republic of Tatarstan) based on literature data and data obtained by the authors. The natural range of natural concentrations has been determined. A comparison of the concentrations of microelements obtained by different authors made it possible to establish that the microelements contents in herbaceous plants of the Republic of Tatarstan does not exceed the world average clarke. The content of Cu and Zn tends to the lower limit. The identified tendency for the trace elments accumulation in plants allows to conclude about a relatively favorable biogeochemical situation in the republic as a whole. Individual local biogeochemical specializations of plants are determined by the natural geochemical background of the region.

1 Introduction

Increasing environmental pollution every year and the negative consequences caused by it put forward the need to study the processes of migration of chemical elements in natural ecosystems. Particularly dangerous are trace elements, which, unlike a number of other man-made pollutants (surfactants, pesticides, petroleum products, etc.), are not subject to degradation processes, but only change their forms of presence in environmental components. As promising cumulative indicators of trace element pollution, we should note higher terrestrial plants that lead a lifestyle attached to a certain area of the terrain and, therefore, are not capable of purposefully avoiding geochemical stress. Thus, studying the content of trace elements, most of which belong to the group of heavy metals, in the components of natural ecosystems, along with classical methods of bioindication, will make it possible to control the degree of transformation of biogeochemical cycles under the influence of intense technogenic impact on the biosphere.

Despite the abundance of research results aimed at establishing natural (background) concentrations of trace elements in the soil landscape of the Republic of Tatarstan (RT), the degree of knowledge of the distribution of trace elements in the vegetation of the republic leaves much to be desired. The available literature contains only fragmentary information on the concentration of trace elements in plants of some ecosystems of the RT [1-5]. This

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served as the reason for summarizing the available literature and materials obtained by the authors on the content of trace elements in vegetation.

2 Trace elements in plants according to literary data

The Republic of Tatarstan is located in the centre of the Russian Federation on the East European Plain, at the confluence of two largest rivers – the Volga and the Kama. Tatarstan is part of Middle Volga region.

Comprehensive biogeochemical research in the Republic of Tatarstan began to be carried out in the 90s. B.R. Grigoryan et al. [3] studied the content of trace elements in the components of terrestrial and aquatic ecosystems in the Mesha River valley. The concentrations of trace elements in the above-ground and underground plant phytomass are determined by belonging to the soil types characteristic of the Mesha floodplain (Table 1). According to these data, plants accumulate more trace elements in their roots. At the same time, the barrier function of the root system is most intense on alluvial meadow soils and floodplain soddy-podzolic soils. Due to the direct dependence of the content of trace elements in plants on their concentration in the soil, established in the work, this fact is due to the increased content of trace elements in alluvial meadow and floodplain soddy-podzolic soils compared to alluvial soddy soils. Cattail, especially its rhizome, was identified as an intensive accumulator of all studied elements.

Table 1. Content of heavy metals in the aboveground (above the line) and underground (below the line) phytomass of meadow vegetation of the Mesha floodplain (according to B.R. Grigoryan et al. [3])

Soil type and plant associations	Ash content, %	Trace elements, mg/kg of dry weight							
		Fe	Mn	Zn	Ni	Cu	Pb	Cr	Cd
I	7.6 / 6.0	347.6 / 781.7	45.7 / 50.1	66.3 / 76.1	0.49 / 1.05	5.3 / 9.6	0.09 / 0.15	0.51 / 0.79	0.06 / 0.04
II	8.7 / 7.2	318.3 / 1233.9	44.6 / 50.7	20.8 / 89.6	1.10 / 3.02	4.0 / 11.1	0.19 / 0.22	0.51 / 1.29	0.07 / 0.11
III	6.7 / 5.8	157.5 / 569.9	44.5 / 49.7	35.7 / 90.6	1.95 / 4.13	4.6 / 7.0	0.10 / 0.24	0.15 / 0.67	0.11 / 0.15

Note. I – alluvial turf, meadow forbs with a predominance of bluegrass and fescue; II – alluvial meadow, meadow forbs with a predominance of cereals; III – floodplain soddy-podzolic, meadow forbs with dominant Poa angustifolia and Asteraceae.

B.R. Grigoryan et al. [2] also determined the content of metals in cereals, legumes, and vegetable crops in the Eastern Predkamje of the Republic of Tatarstan. It has been established that the mobility of Cd in the soil-plant system is higher than that of Pb. Its excess content was revealed in buckwheat, especially when grown on gray forest soils, as well as in the green mass of alfalfa on chernozems. Ni concentrations in plants were determined to be 3-3.5 times higher than its normal level, which is comparable to its content in soils.

R.H. Sungatullin et al. [5] studied the biogeochemical state of vegetation in the Naberezhnye-Chelninskaya area. Based on the results of cluster and factor analyses, the studied chemical elements of plants were combined into three groups – lithophilic, biophilic, technophilic. The first group consists of Al, Fe, Ti, V, Nb, Zr, Y, Yb, Sc, Be, that is, elements of Permian, Neogene and Quaternary clays, sandstones, sands. The share of the “lithophilic factor” is more than 25% of the volume of all geochemical information contained in plants; therefore, it is the composition of soil-forming parent rocks that is the determining factor in the chemical appearance of plants in the Naberezhnye-Chelninskaya area. Elements of the second group (Na, Ca, P, Mg, Mn, B, Cu, etc.) play an important role in the life of plants. The third group combines elements (Pb, Cr, Ni, Mo, Ga, Co, As, Cu), which are associated with the industrial-urban load of the region and enter plants with dust, precipitation and groundwater. There is a tendency for the strength of bonds between elements to decrease when moving from the “lithophilic” group, which is associated with an expansion in the number of elements involved by humanity in the “geochemical cycle”.

When analyzing plants growing on different types of soil, R.Kh. Sungatullin et al. [5] identified their geochemical features. For example, on soddy-podzolic soils, Ba, V, and Mn are concentrated in plants, and to a lesser extent, Al and Zn. Chernozems are dominated by plants with high concentrations of Sr, which are significantly depleted in Mn and Ni. Among the studied plants, the main concentrator of chemical elements is moss, in the ash of which anomalous contents of 19 elements were established: As, Sc, Pb, V, Mn, Cr, Ga, Ge, Y, Yb, Zn, Fe, Co, Ti, Ni, Al, Zr, Nb and Li. Among trace elements, Mn stands out especially, which accumulates in 26 tested species. This fact confirms its concentration in the weathering crust of Permian deposits. Taking into account the fact that the latter occupy about 80% of the study area, the weathering crust can be considered as a zone for plant nutrition with manganese. Among trace elements, it is also necessary to note Co, which accumulates in groundsel, mosses, knotweed, willow, wild ginger, coltsfoot, rank, birch, etc.

F.S. Bilalov et al. [1] when studying the content of Cu, Zn, Pb, Cd, Ni, Fe in the components of ecosystems of Kazan and adjacent territories (Saralinsky and Raifa area of the Volga-Kama State Natural Biosphere Reserve) it was shown that plant samples from the Raifa area are characterized by increased Zn content and high Cd content at the level of 2.3 MAC [6].

D.V. Ivanov [4], when studying the content of heavy metals in the components of island ecosystems of the Kuibyshev Reservoir, identified the concentrating families Pb – Labiatae and Polygonaceae, Ni – Polygonaceae and Rosaceae, Zn – Rosaceae and Poaceae, Mn – Polygonaceae and Rosaceae, Cr – Poaceae.

Among the plant species characterized by a higher content of microelements relative to other species, the following were identified (mg/kg dry weight): Pb – mountain clover (1.0), angustifolia bluegrass (1.1), asparagus (1.2), horse sorrel (1.1); Cu – oregano (18.4), mountain clover (14.5), consumptive grass (16.1), meadowsweet (14.5); Ni – dense sorrel (16.7), white bentgrass (11.6), meadowsweet (9.4). It should be noted that the Ni content in plants of the first two species is beyond the limits of normal physiological concentrations [7]. Zn – woodlice (256.4), angustifolia bluegrass (142.6). The Zn content of these two species is also in the range of excess, or toxic, concentrations [7]. Cr – angustifolia bluegrass (3.1), seaside sorrel (2.2). Mn – horse sorrel (730.9), angustifolia cattail (508.7), sedge (all species) (539.7), angustifolia bluegrass (323.0), loosestrife (513.3). It should be noted that the critical concentration of Mn is considered to be 300 mg/kg, phytotoxic - more than 500 mg/kg [7]. The soils of the islands of the Kuibyshev Reservoir are also characterized by a high Mn content, which is due to its hydrogenic supply from groundwater.

It has been established that vegetation, topoecologically confined to the channel facies of alluvium, is characterized by the accumulation of Pb, Ni, Zn, Cr, Mn (on ash) maximum, confined to the oxbow alluvium – medium, gravitating to the floodplain alluvium - minimum level. Thus, the absolute content of heavy metals in the vegetation of island ecosystems is to a certain extent mediated by the facial geochemical situation, therefore, plant associations confined to the considered facial groups of alluvial deposits exhibit a natural change in their trace element composition [4].

E.R. Ivanova [8] found an increased background content of Cr and Ni in vegetation on the territory of the South-Eastern Zakamje region of the Republic of Tatarstan, due to the relative enrichment of the soil cover with these elements. B and Mn accumulate mainly in birch, Zn - mainly in birch and rarely in shrubs, Cd – only in grasses.

R.G. Ilyazov et al. [9] studied the heavy metals content Pb, Cd, Cu, Zn in summer feeds, including meadow forbs of a number of farms in the South-East of the Republic of Tatarstan. 15% of the feed was contaminated with Pb above the standard values at a concentration of up to 1.6 above the MAC, Cd – 60.6%, exceeding the MAC by 4.3 times and Zn – 9% at a concentration exceeding the standard by 1.55 times. The authors note that the concentration of Pb and Cd in alfalfa plants growing at a sufficient distance from the road (50-100 m) exceeded the MAC. During the grazing period, the levels of heavy metals in green mass brought from cultivated pastures and meadows to feed cows before milking can significantly affect the environmental safety of milk.

3 Trace elements in plants according to own study

Own biogeochemical research of 2006-2007 covered the areas of Western Predkamje (Pestrechinsky, Mamadyshsky, Zelenodolsky districts), Eastern Zakamje (Almetyevsky, Bugulminsky districts), Predvolzhje (Verkhneuslonsky district) of the RT and the Kazan city (Table 2). As a result of this research the content of trace elements was studied using atomic absorption spectrometry Fe, Cu, Zn, Pb, Cd in 90 species of wild plants [10]. Based on the background content of metals in plants, the following series was constructed (mg/kg dry weight): Fe (63.5) > Zn (10.8) > Cu (3.0) > Pb (0.7) > Cd (0.1). The median (50th centile) was taken as the regional background content of trace elements, reflecting their natural content in terrestrial vegetation, from which anomalous values of trace element contents (abnormally high and low) were excluded.

According to the landscape zoning of the Republic of Tatarstan [11], the studied territories of the Verkhneuslonsky and Pestrechinsky districts belong to the broad-leaved subzone (subboreal northern semi-humid landscape zone), Zelenodolsky and Mamadyshsky districts – to the subtaiga subzone (boreal landscape zone), Almetyevsky and Bugulminsky districts – to the typical and southern forest-steppe subzone (subboreal northern semi-humid landscape zone).

A comparative analysis of the concentrations of trace elements in plants confined to different landscape subzones showed that herbaceous plants of the typical and southern forest-steppe subzone are characterized by increased contents of Fe (84 mg/kg) and Cu (5.4 mg/kg), and plants of the subtaiga subzone – Zn (14.9 mg/kg), Pb (1.9 mg/kg), Cd (0.4 mg/kg). However, this picture is typical for average indicators. It is known that the accumulation of trace elements by plants is influenced by a whole complex of factors. The studied biotopes belong to different phytocenoses, are confined to different types of soils with different ecological and geochemical conditions and are characterized by different levels of anthropogenic impact. The most important factor in the accumulation of trace elements by plants is their species specificity. Therefore, the content of trace elements in individual plant species is characterized by significant variation. The concentrations of Cu in plants of different species differed by 31 times, Fe by 28 times, Zn by 62 times, Pb and Cd by more than 1000 times.

When averaging the obtained concentrations of elements in plants of various types of phytocenoses, it was found that plants growing in broad-leaved forests had the lowest content of Cu and Pb. Plants of urban phytocenoses (Kazan) are characterized by a higher content of Cu and Fe. Plants growing in meadow phytocenoses are characterized by an increased content of Cu. Plants of coniferous phytocenoses are distinguished by a higher content of Zn compared to plants of broad-leaved forests.

Correlation analysis of data on the content of elements in plants and soils showed the presence of a significant positive correlation between the content of Zn, Pb, Cd, K and Ca in plants and the content of mobile forms of these same elements in the soil. It has also been established that the behavior of Zn and Pb in the soil-plant system is largely determined by the content of organic matter in the soil, and the content of Cd in plants depends on the reaction of the soil environment.

The geochemical specialization of plants growing on different types of soils, determined by the genesis and granulometric composition of the soils, has been established. Thus, plants growing on typical soddy-carbonate soil are characterized by an increased content of Fe (178 mg/kg), which is 2-4 times higher than the content in plants of other types of soil, and Cu (7 mg/kg). In contrast to the results of R.Kh. Sungatullin et al. [5], according to our data, plants on soddy-podzolic soils were significantly enriched with Zn (18.5 mg/kg).

Increased concentrations of microelements relative to other species were found in plants of the following species: Cu – in plants of wormwood (12.12 mg/kg, Kazan), Fe – in plants of creeping thyme (456 mg/kg, Bugulminsky district), Zn – in plants of greater celandine (113 mg/kg, Zelenodolsky district), Pb and Cd – in plants of field bindweed (33.17 mg/kg and 4.41 mg/kg, respectively, Zelenodolsk district). At the same time, intensive accumulation of microelements Cu and Zn, measured by the value of the biological absorption coefficient (BAC) exceeding 100, is typical for boneberry, lingonberry, and wild strawberry plants.

In wild medicinal plants of a local area in the Zelenodolsky region of the RT, an increased content of standardized elements was revealed. Pb content at the level of 2.0-5.5 MAC was found in plants of great white daisy, St. John's wort, silverweed, ground reed grass, and field bindweed. Accumulators of Cd (1.3-4.4 MAC) are common coltsfoot, common toadflax, soft bedstraw, thin bentgrass, wild strawberry, and field bindweed.

It has been established that the organ specificity of Pb and Cd depends on the level of technogenic load on the territory: in its absence, Pb and Cd accumulate in the root system, and under conditions of technogenic load – in generative organs. Fe has an acropetal distribution; Cu and Zn predominantly accumulate in generative organs.

The results of biogeochemical studies of the herbaceous vegetation of the RT by different authors are summarized in Table 2. For comparison with the standards, the maximum allowable concentrations (MAC) of standardized elements for plants that can be used for various purposes are given.

Table 2. Trace elments ontent in herbaceous plants of some ecosystems of the Republic of Tatarstan, mg/kg dry weight

Study area	Cu	Fe	Zn	Pb	Cd	Ni	Cr	Mn	Co
Islands of the Kuibyshev Reservoir [4]	7.7		33.3	0.4		2.8	0.4	95.4	
Kazan city [1]	20.2	1102	80.4	6.5	1.5	8.3			
Kazan city (*Gramineae*) [14]	4.3		13.6	2.5	0.2				
Kazan city [17]			24.4		0.5				
Kazan city	2.7	89.4	12.2	2.4	0.7				
Saralinsky area of Volga-Kama state nature biosphere reserve [1]	10	299	69.3	0.25	0.7	3.7			
Raifa area of Volzhsko-Kamsky state nature biosphere	15.2	525	121.1	3.5	2.3	17.1			

reserve [1]									
Raifa area of Volga-Kama state nature biosphere reserve [15]	4.6	129	30	1.3	0.2	2.0	0.4	127	0.3
«Lower Kama» national park [12]	5.9	154	33.4	1.1	0.2	3.1	1.7	291	0.5
Naberezhnoe-Chelninskaya acrage [5]	8-50*	1000-17500*	5-160*	2-25*		3-40*	5-200*	100-20000*	
South-East of the Republic of Tatarstan [14]	5.0		18.9	3.7	0.2				
South-East of the Republic of Tatarstan (разнотравье луговое) [9]	0.9-10.7 (3.8)		4.6-56.0 (19.3)	0.1-4.8 (2.1)	0.08-0.6 (0.4)				
South-East of the Republic of Tatarstan [8]	5.0		33.0	4.0	0.2	4	2.5	186	0.6
Western Predkamye	2.6	62.5	12.6	1.2	0.1				
Eastern Predkamye	5.4	83.8	9.8	0.3	0.1				
World average content of trace elements in land plants [7]	5-30	50-300**	27-150	5-10	0.05-0.2	0.1-5	0.1-0.5	20-300	0.02-1
MAC in food products [6]				6	1				
MAC in artificially dried grass feeds and hay [18, 19]	30		50	5	0.03				
MAC in green plants silage [20]	30		50	5	0.3				

Note. The average contents of elements are given in parentheses; * the values of the trace elements content are indicated, given in mg/kg of ash; ** - according to Baker (1983) (cited by Bityutsky [21])

The obtained results on the Cu content in plants of the Zakamje are consistent with the literature data on the Cu content in the vegetation of the Zakamje of RT [8], but the content of Zn, Pb and Cd turned out to be lower. The concentrations of Pb and Cd in plants of the Zakamje coincide with the data of R.G. Ilyazov [9], values of Pb content in plants of the Predkamje – with the data from D.V. Ivanov [4]. We did not find any literary data on the trace elements content in wild plants of the Predvolzhje.

Based on the results of a study of the trace elements content in 14 wild herbaceous plants of the «Lower Kama» National Park [12], species with an increased Ni content relative to the average level in terrestrial vegetation of the world were found – drupes (8.2 mg/kg) and Dutchman's-pipe (18.3 mg/kg). kg). High concentrations of Fe (>1000 mg/kg), Cr (≥20 mg/kg), Pb (≥2 mg/kg) were revealed in the phytomass of mosses compared to species of flowering plants. This is due to the aerogenic supply of these elements from nearby industrial enterprises in Naberezhnye Chelny and Yelabuga, since the absence of a root system in mosses practically eliminates the contribution of other sources other than atmospheric fallout.

It has been established that herbaceous plants with different degrees of expression of adaptive strategies significantly differ in Zn content. It is noted that the absence of statistically significant differences in the content of other metals between plants of different types of adaptive strategies, obtained as a result of the study, does not indicate the absence of such correlation in principle and may be caused by the limited volume of the studied material. We can say that a tendency has been discovered towards the preferential accumulation of certain metals by plants with different types of adaptive strategies, confirming the patterns previously identified by a small number of authors. Plants of transitional strategy types are prone to more intense accumulation of Zn, Cu, Pb, Cd. It was found that patients accumulate the studied elements in greater quantities than explerents and violents.

The study also established the features of trace elements accumulation by plants of different ecological groups according to the type of regulation of water metabolism, most likely associated with different rates of transpiration. The content of the studied metals in plants decreases in the order: mesophytes → xerophytes → mesohygrophytes. However, the results obtained require clarification with the simultaneous determination of indicators of air humidity, soil and transpiration intensity in field conditions [13].

A fundamental difference in the intensity of biological accumulation of anionogenic and cationogenic elements by photosynthetic organs of wild plants of the RT has been mathematically revealed. Using the regression analysis method, it is shown that the intensity of absorption of cationic chemical elements by plants can be predicted taking into account the ionic radius and adjusted for the coefficient of retention by the root system (for example, lead), and anionic elements – taking into account the energy constant (EC) according to Fersman and soil type. The role of plants in the biogenic migration of anionogenic elements with high EC (> 31) is negligible.

Based on experimental data on the trace elements content (Zn, Cu, Cd, Mo, Co, Ni, Mn, Sn, Cr, Pb, B, V, Ag) in the photosynthetic organs of plants in mixed forests of the South-East of the RT and Kazan city and the intensity bioabsorption of elements, the biogeochemical activity (BCA) of plants of three tiers is characterized depending on growing conditions: the biogeochemical activity of plants in mixed forests (BCA 17.5÷33.7) is generally higher than that determined for plants in urban areas (10.2÷28.3); BCA for herbaceous vegetation, birch and pine is statistically insignificant, and for shrubs and linden it decreases when moving from the conditions of the South-East of the RT to the conditions of the city.

Using the example of forest park zones in Kazan city, composed of gray forest sandy and sandy loam soils, it is shown that the content of heavy metals (Pb, Ni, Cd, Cr, Zn) in the photosynthetic organs of plants practically does not depend on the content of mobile forms in the soil cover, and for most of the metals studied and for gross content. Only a significant trend ($r > r_{cr}$) was revealed towards an increase in the content of Mn and Cu with an increase in their total content in the soil cover for grasses and shrubs, and shrubs are more «responsive» to the Mn content in the root zone than herbaceous plants. The absorption limit of Cu for herbaceous plants is detected at $n_x \geq 14.9$ mg/kg of dry soil; for shrubs, a similar absorption limit is not reached until $n_x = 102$ mg/kg of dry soil.

The average intensity of absorption of a number of elements (B, Mn, Zn, As, Cr, V and Ni) for each of the studied life forms of plants generally does not depend on the type of geochemical landscape (eluvial, transit, trans-accumulative, accumulative) while maintaining individual values BAC: B, Mn and Zn are elements of energetic accumulation as the most physiologically significant and As, Cr, V and Ni are elements of weak absorption, the physiological role of which has not been proven. A characteristic dependence was revealed for Pb: while for herbaceous plants there is no dependence on the type of landscape, then for shrubs and trees the intensity of absorption decreases in transaccumulative and accumulative landscapes. The influence of landscape type on the intensity of absorption of Cu and Mo does not manifest itself in the form of any dependence due to the more complex influence of other factors.

The intensity of absorption of Zn, Cd, Cr and Pb for each of the studied layers of vegetation growing in the forest park zones of Kazan city does not depend on the type of functional use of the urban area. These elements are divided into two groups with limiting BAC values: Zn and Cd with BAC > 1 and Cr and Pb with BAC < 1. The intensity of absorption of Cu and Ni from urban soils is higher for plants growing in industrial zones; no pattern is detected for Co [14].

When studying the trace elements content in plants of the Volga-Kama Biosphere Reserve [15], the geochemical specialization of plants was established depending on the lithological characteristics of the soils. Mn and Cu in plants on soddy-podzolic soils formed by aeolian sands and sandy loams accumulate in greater quantities than in plants on soils composed of alluvial-deluvial deposits. In the latter, on the contrary, an increased content of Fe and Zn was noted. The biogeochemical activity of species is more intense on soils formed by aeolian sands, due to their relatively low supply of trace elements available for absorption. Along with the species-specific nature of the trace elements accumulation by plants, an unequal distribution of trace elements in different parts of plants was revealed: the distribution of Ni, Cu, Cd in ferns is basipetal, and the content of Mn, Fe, Zn, Pb and Cu is acropetal; Fe, Ni, and Co in flowering plants accumulate in an acropetal manner, and Cd in a basipetal type.

The natural trace elements content in plants, as well as in soils, is characterized by high natural variation. Background concentrations in plants, even within the same landscape, can vary several times, so it is important to have an idea of the natural variation of these indicators.

4 Conclusion

Thus, according to various authors, the trace elements content in plants of the Republic of Tatarstan does not exceed the world average. The content of Cu and Zn tends to the lower limit. Attention should be paid to the results of Bilyalov et al. [1], which turned out to be significantly higher than both the global average values and the MAC for all trace elements.

It is shown that for most trace elements, the regional background according to various authors is lower or does not significantly exceed the average level of microelements in the world's terrestrial vegetation. The range of regional background concentrations of standardized elements in wild plants, determined by different authors (Tables 1, 2), does not exceed the MAC in food and MAC in feed.

Wild herbaceous plants, in addition to their indicator role in assessing the biogeochemical situation in natural phytocenoses and the ecological state of ecosystems in general, are also a source of medicinal plant materials and an important feed resource. In this regard, the content of heavy metals in wild plants is the most important indicator of the biological and hygienic quality of plants. To assess the safety of medicinal plants based on their Pb and Cd content for human health, the obtained concentrations of metals in plants can be compared with the values of the maximum permissible concentrations of Pb (6 mg/kg) and Cd (1 mg/kg) in plant-based dietary supplements (dry teas) [6], and to assess the safety of feed also with the values of maximum permissible levels [16] in feed.

The scatter in the values of the background content of elements is due to the high degree of variability in the soil properties of the studied areas, sites, and landscapes, which, as is known, is determined by the humus content, particle size distribution, acid-base, redox, weather and climatic conditions at a particular point in time. In this work, we did not set a goal to identify the dependence of the metal content in plants on a specific soil type and soil properties. We wanted to determine the range of background concentrations of trace elements characteristic of vegetation growing in the Republic of Tatarstan in Middle Volga conditions, which, despite the difference in the figures of different authors, can be determined from Table 2.

Thus, the identified tendency for the trace elements accumulation in plants allows us to conclude about a relatively favorable biogeochemical situation throughout the republic as a whole, with the exception of certain local areas, which were mentioned above. In connection with the identified areas in natural phytocenoses with an increased content of standardized metals in plants, there is a need to continue ecological and biogeochemical studies of wild vegetation in order to obtain more complete and accurate information about the characteristics of the trace elements composition of wild plants in in Middle Volga conditions.

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