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HEAVY METAL CONTENTS IN PLANTS OF PHYTOCENOSES OF THE POINT OF BESQAYNAR, KYZYLKAIRAT AND TAUKARATURYK

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Abstract

This article presents data on the determination of heavy metals (Pb^{+2}, Zn^{+2}, Cu^{+2}, Fe^{+2}, Ni^{+2}, Co^{+3}, Mn^{+2}, Cr^{+2}, Cd^{+2}) in plant samples collected from Almaty Region, Talgar District of Kazakhstan. For a number of reasons, plants cannot absorb most of the heavy metals and, unlike animals, are able to accumulate them in large quantities. The following points were selected for sampling: Control point – Taukarutuk, 2 point – Besqaynar and 3 point – Kyzylkairat. *Rumex confertus, Artemisia annua, and Trifolium pratence* were identified as the most highly accumulating species of heavy metals in all three monitoring groups. It was investigated that, in the studied points, Besqaynar and Kyzylkairat, all presented plant samples have a large adsorption capacity for such elements as Cd^{+2} and Zn^{+2}.

Key words: Almaty region, Heavy metals, *Artemisia annua*, *Bromus inermis*, *Rumex confertus, Trifolium pretense*.

Introduction

Plants are vulnerable component of biota and e primary link in the trophic chain. They play a major role in the absorption of variety of pollutants as theyconstantly exposed to pollutants due to attachment to the substrate. On the other hand, the natural settlement of plants leads to the formation of various plant communities growing on soils contaminated with technogenic factors (Nurzhanova *et al*., 2014, Cunningham & Ow, 1996).

Any metal or metalloid species may be considered a «contaminant» if it occurs where it is unwanted or in a form or concentration that causes a detrimental human or environmental effect (Mcintyre, 2003; Singh *et al.* 2011). Changes in dissolved metal concentrations and species greatly influenced metal uptake by plants. Plant uptake was primarily related to the concentrations of metals in the soil solution rather than the total metal concentrations of the soil (Kim *et al.* 2010). Heavy metals such as lead, arsenic, selenium, cadmium, copper, zinc, uranium, mercury, and nickel are found to be responsible for posing serious health risks due to transfer of these contaminants into food chain. Nutrient enriched soil is a basic constituent for food production. Due to excessive use of agrochemicals and changing environmental conditions; heavy metals are being accumulated in soils and are posing a serious threat to human life (Wong *et al.,* 2003; Nicholson *et al.*, 2003; Qaiser *et al.*, 2013).

One of the characteristic features of the modern stage of development of society is the strengthening of anthropogenic impact on the environment. This process is accompanied by synergistic effects and leads to the deterioration of the natural environment, which, in the long term, leads to a reduction in biodiversity [Lebedeva *et al*., 2002]. Plants possess a wide range of responses and reactions to environmental pollution towrds heavy metals. Plants can be divided into accumulators and excluders according to the ability to accumulate heavy metals in the organs (Baker *et al.*, 1994, Nevedrov *et al.*, 2019).

In 2014-2017, within the framework of the project Biodiversity of vascular plants of Trans-Ili Ala-Tau and the development of recommendations for the rational use of economically valuable plants and conservation of rare and endangered species, the authors conducted studies on the current state of flora and vegetation of the Ile Alatau (Small and Large Almaty gorge, Remizovka, Talgar, Kaskelen, Turgen, Esik, Bertagoy, Aksai, big Dalan Plateau; Baitulin *et al.*, 2017).

It was also studied from 2002 to 2013 by Nurzhanova and others biodiversity of plants of Almaty region is point in places of the former warehouses of storage of pesticides (Nurzhanova, 2007, Kalugin *et al.*, 2013, Nurzhanova *et al.*, 2013, Nurzhanova *et al.*, 2015, Nurzhanova *et al.*, 2009, Nurzhanova & Aidosova, 2006, Nurzhanova *et al.*, 2014, Nurzhanova *et al.*, 2015, Inelova *et al.*, 2010, Karthikeyan *et al.*, 2002, Nurzhanova *et al.*, 2003, Karthikeyan *et al.*, 2003, Nurzhanova *et al.*, 2003, Karthikeyan *et al.*, 2003, Nurzhanova *et al.*, 2003, Nurzhanova *et al.*, 2005, Nurzhanova *et al.*, 2006).

Materials and Methods

Before the beginning of the work, routes were laid to the Almaty Region, Talgar District (Fig. 1) for which sampling of plants, soil cover was carried out to identify the accumulation heavy metals.

The plant samples were collected at three points:

1 Point (v. Besqaynar, destroyed warehouse) N 43°13.274´ E 077°06.829´

2 Point (v. Kyzyl Kairat) N 43°17.963´ E 077°11.682´

3 Control Point (Taukaraturyk Village, Enbekshikazakh District) N 43°29.352´ E 078°01.230´

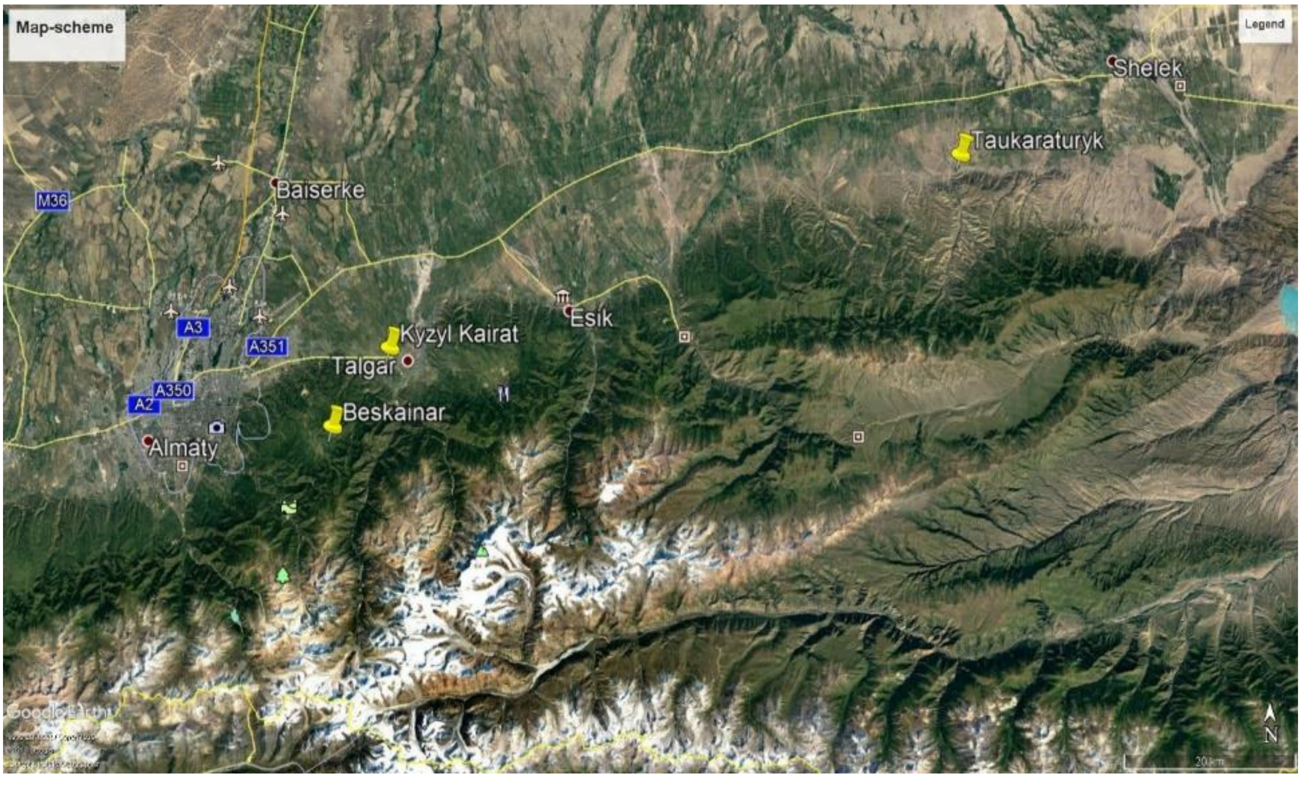

Fig. 1. Sampling sites of Almaty Region, Talgar District.

To identify tolerant plant species capable of accumulation (use this word, if they are heavy metals. Hevay metals cannt be degraded.) or degradation (use this word, if they are organic compounds. Organic matters can be degraded.), the species saturation of phytocenoses in the territories was studied. To solve the tasks in each region, three typical experimental plots of 10 m^2 were selected. At each site, three sites with an area of 1 m^2 were selected by random sampling. The main research methods were geobotanical and floristic using plant bioindicators (Lavrenko & Korchagina, 1959; Lavrenko & Korchagina, 1960; Lavrenko & Korchagina, 1964; Lavrenko & Korchagina, 1972). The measurement technique for heavy metals was carried out by atomic absorption spectrometry (Ilyin & Syso, 2001; Kostyuk *et al.*, 2000; Zhuravleva, 1974). Determination of heavy metals in samples was carried out by traditional methods by comparative analysis with the existing indicators of maximum permissible concentration (MPC), as well as with the data of control samples of the region with similar climatic conditions without special anthropogenic pressure (Almaty Region, Control: Village Taukaratyryk, Enbekshikazakh District).

Dominants and forage plants of 3 points of Almaty region were identified, which later served as objects of research of forage and dominant plants – *Artemisia annua*, *Bromus inermis*, *Rumex confertus*, *Trifolium pratense*.

The determination of heavy metal content in the plant samples was conducted using the atomic absorption spectrometer AAS-1N (Slavin, 1993; Li *et al*., 2016).

Results and Discussion

For the analysis were selected dominant plant species: *Bromus inermis (Leyss.) Holub, Rumex confertus Willd*, *Trifolium pratense* L., *Artemisia annua* L. The collection of plants was carried out in the studied points according to the traditional scheme. The samples of plants were determined by the content of the following metals: lead, cadmium, zinc, copper, iron, nickel, cobalt, manganese, chromium (Table 1).

In the samples of plants (*Bromus inermis*, *Rumex confertus*, *Trifolium pratense*, *Artemisia annua*), selected in Besqaynar, the following content of heavy metals not exceeding the permissible rate was found. For example, in samples of *Bromus inermis* lead content (0.51 MPC), zinc (1 MPC), copper (0.70 MPC), iron (0.12 MPC), nickel (0.13 MPC), cobalt (0.32 MPC), manganese (0.34 MPC), chromium (0.10 MPC) within acceptable limits. In samples of *Rumex confertus*, the content of lead (1 MPC), copper (0.85 MPC), iron (0.17 MPC), nickel (0.06 MPC), cobalt (0.28 MPC), manganese (0.36 MPC), chromium (0.08 MPC) is within the limits of permissible. In samples of *Trifolium pratense* the content of copper (0.86 MPC), iron (0.19 MPC), nickel (0.06 MPC), cobalt (0.26 MPC), manganese (0.35 MPC), chromium (0.03 MPC) is within acceptable limits. The samples of *Artemisia annua* contain lead (0.79 MPC), copper (1 MPC), iron (0.15 MPC), nickel (0.06 MPC), cobalt (0.34 MPC), manganese (0.35 MPC), chromium (0.03 MPC) is within acceptable limits.

In the samples of plants *Bromus inermis*, *Rumex confertus*, *Trifolium pratense*, *Artemisia annua*, selected in Besqaynar, the following heavy metal content exceeding the allowable rate was found: *Bromus inermis* (cadmium - 4 MPC), *Rumex confertus* (cadmium - 3.8 MPC, zinc - 1.12 MPC), *Trifolium pratense* (blue - 1.63 MPC, cadmium - 2.1 MPC, zinc - 1.2 MPC), *Artemisia annua* (cadmium - 3.24 MPC, zinc - 1.44 MPC) (Fig. 2).

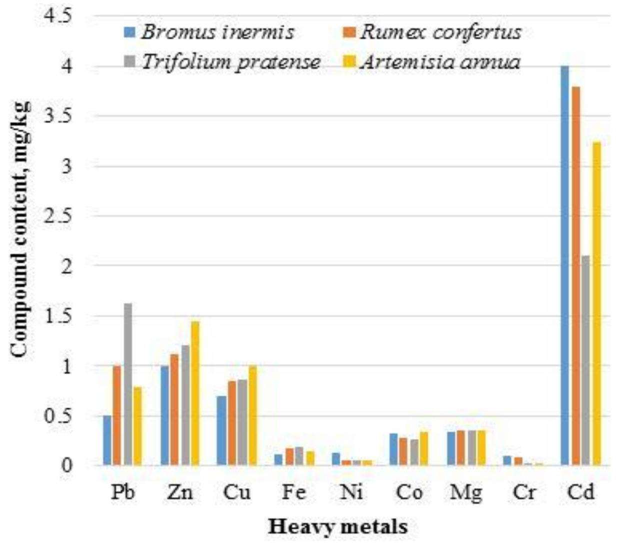

Fig. 2. The contents of heavy metals in plants at the point Besqaynar.

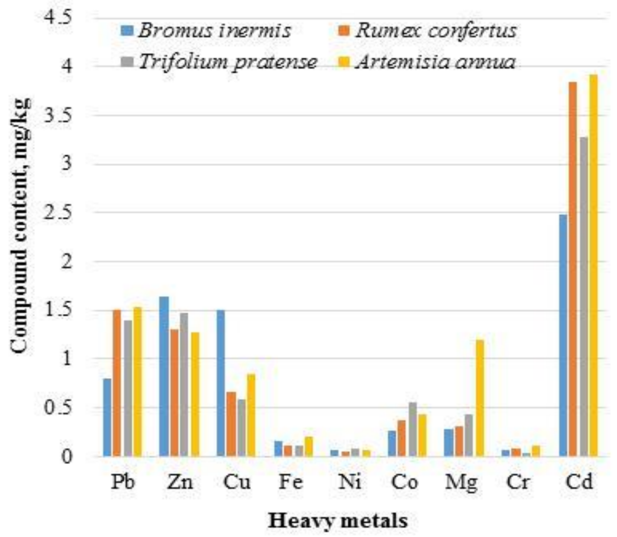

Fig. 3. The content of heavy metals in plants at the point Kyzylkairat.

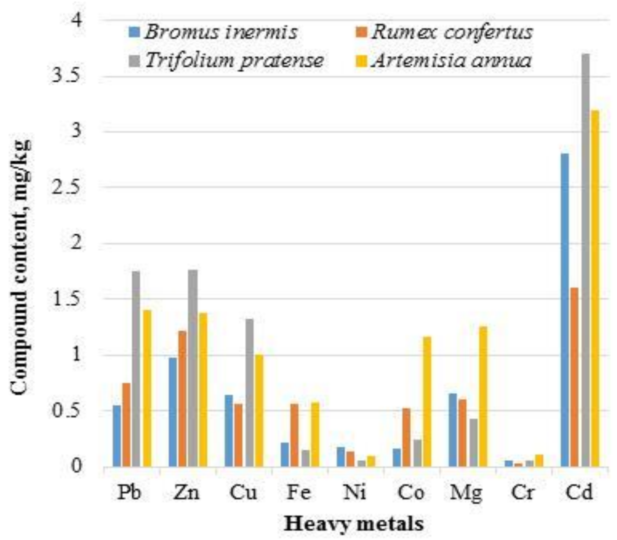

Fig. 4. The content of heavy metals in plants at the control point Taukaraturyk.

Table 1. Content heavy metals in plant samples taken from collection sites.

Collection sites	Plant species	Compound contenta (mg kg^{-1})								
		Pb^{+2}	Cd^{+2}	Zn^{+2}	Cu^{+2}	Fe^{+2}	Ni^{+2}	Co^{+3}	Mn^{+2}	Cr^{+2}
Taukaraturuk	*Bromus inermis*	2,20 ± 0,18	**1,40 ± 0,12**	49,20 ± 5,32	6,42 ± 0,58	158,20 ± 16,22	14,80 ± 1,24	0,80 ± 0,07	162,00 ± 15,34	6,40 ± 0,62
	Rumex confertus	3,00 ±0,25	**0,80 ± 0,07**	**61,20 ± 5,60**	5,60 ± 0,50	420,00 ± 30,60	11,20 ± 1,03	2,60 ± 0,22	150,00 ± 14,25	4,00 ± 0,35
	Artemisia annua	**5,62± 044**	**1,60 ± 0,14**	**68,40 ± 6,45**	**10,00 ± 1,22**	434,10 ± 36,43	7,60 ± 0,64	**5,80 ± 0,50**	**312,00 ± 26,15**	12,80 ± 1,30
	Trifolium pratense	**7,00 ± 0,58**	**1,85 ± 0,16**	**88,20 ± 7,60**	**13,21 ± 1,30**	114,80 ± 12,50	5,60 ± 0,50	1,20 ± 0,10	108,00 ± 10,62	6,42 ± 0,58
Besqaynar	*Bromus inermis*	2,05 ± 0,15	**2,00 ± 0,18**	**50,42 ± 4,16**	7,00 ± 0,68	92,40 ± 8,94	11,60 ± 10,30	1,58 ± 0,14	84,05 ± 7,15	11,20 ± 1,08
	Rumex confertus	4,00 ± 0,34	**1,90 ± 0,18**	**56,00 ± 5,20**	8,50 ± 0,72	128,10 ± 13,20	4,80 ± 0,52	1,40 ± 0,12	90,00 ± 9,44	8,80 ± 0,76
	Trifolium pratense	**6,52 ± 0,56**	**1,05 ± 0,09**	**60,00 ± 5,64**	8,62 ± 0,80	141,40 ± 13,86	5,00 ± 0,44	1,28 ± 0,11	87,00 ± 8,20	3,20 ± 0,27
	Artemisia annua	3,15 ± 0,28	**1,62 ± 0,15**	**72,05 ± 6,92**	9,91 ± 0,92	110,60 ± 10,38	5,20 ± 0,48	1,68 ± 0,15	72,00 ± 6,36	3,00 ± 0,25
Kyzylkairat	*Bromus inermis*	3,20 ± 0,25	**1,24 ± 0,12**	**82,20 ± 7,50**	**15,00 ± 1,64**	121,82 ± 12,63	5,40 ± 0,52	1,32 ± 0,12	69,00± 7,50	6,44 ± 0,60
	Rumex confertus	**6,04 ± 0,55**	**1,92 ± 0,18**	**65,40 ± 6,15**	6,61 ± 0,68	91,70 ± 9,67	4,32 ± 0,26	1,84 ± 017	78,00 ± 7,00	9,60 ± 0,72
	Trifolium pratense	**5,56 ± 0,46**	**1,64 ± 0,14**	**73,82 ± 6,75**	5,90 ± 0,51	93,81 ± 9,00	7,60 ± 0,65	2,80 ± 0,27	108,00 ± 9,43	4,80 ± 0,42
	Artemisia annua	**6,12 ± 5,64**	**1,96 ± 0,17**	**63,60 ± 5,84**	8,50 ± 0,80	155,42 ±16,20	5,40 ± 0,52	2,20 ± 0,22	300,00 ± 24,00	12,00 ± 1,10

In samples of plants, *Bromus inermis*, *Rumex confertus*, *Trifolium pratense*, *Artemisia annua*, taken in Kyzylkairat, was discovered following the content of heavy metals not exceeding the permissible norm. Thus, in the samples of *Bromus inermis* the content of lead (0.80 MPC), iron (0.16 MPC), nickel (0.06 MPC), cobalt (0.26 MPC), manganese (0.28 MPC), and chromium (0.06 MPC) is within acceptable limits. In the samples of *Rumex confertus* the content of copper (0.66 MPC), iron (0.12 MPC), nickel (0.05 MPC), cobalt (0.37 MPC), manganese (0.31 MPC), chromium (0.08 MPC) is within acceptable limits. In *Trifolium pratense* samples, the content of copper (0.59 MPC), iron (0.12 MPC), nickel (0.09 MPC), cobalt (0.56 MPC), manganese (0.43 MPC), chromium (0.04 MPC) is within acceptable limits. In *Artemisia annua* samples, the content of copper (0.85 MPC), iron (0.21 MPC), nickel (0.06 MPC), cobalt (0.44 MPC), chromium (0.11 MPC) is within acceptable limits.

In the samples of plants *Bromus inermis*, *Rumex confertus*, *Trifolium pratense*, *Artemisia annua* selected in Kyzylkairat, the following heavy metal content was found: *Bromus inermis* (cadmium – 2.48 MPC, zinc – 1.64 MPC, copper – 1.5 MPC), *Rumex confertus* (1.51 MPC lead, cadmium – 3.84 MPC, zinc – 1.3 MPC), *Trifolium pratense* (lead – 1,39 MPC, cadmium – 3,28 MPC, zinc – 1,47 MPC), *Artemisia Annua* (lead – 1,53 MPC, cadmium – 3,92 MPC, zinc-1,27 MPC, manganese-1,2 MPC), which slightly exceeds the permissible level (Fig. 3).

In the samples of plants that are selected as control (*Bromus inermis*, *Rumex confertus*, *Trifolium pratense*, *Artemisia annua*) and experimental samples (*Artemisia annua*, *Trifolium pratense*, *Bromus inermis*, *Rumex confertus*) most of the metals are within the permissible limits. Thus, in the samples of *Bromus inermis*, the content of lead (0.55 MPC), zinc (0.98 MPC), copper (0.64 MPC), iron (0.21 MPC), nickel (0.17 MPC), cobalt (0.16 MPC), manganese (0.65 MPC), chromium (0.06 MPC) is within acceptable norms. In the samples of *Rumex confertus*, the content of lead (0.75 MPC), copper (0.56 MPC), iron (0.56 MPC), nickel (0.13 MPC), cobalt (0.52 MPC), manganese (0.60 MPC), chromium (0.03 MPC) is within acceptable limits. In *Artemisia annua* samples, the content of copper (1 MPC), iron (0.58 MPC), Nickel (0.09 MPC), chromium (0.11 MPC) is within acceptable limits. In samples of *Trifolium pratense* the content of iron (0.15 MPC), nickel (0.06 MPC), cobalt (0.24 MPC), manganese (0.43 MPC), and chromium (0.06 MPC) is within acceptable limits.

However, the content of some heavy metals exceeds the permissible limit.

For example, in samples of *Bromus inermis* cadmium (2.8 MPC), in samples of *Rumex confertus* cadmium (1.6 MPC), zinc (1.22 MPC), *Artemisia annua* lead (1.4 MPC), cadmium (3.20 MPC), zinc (1.37 MPC), cobalt (1.16 MPC), manganese (1.25 MPC), *Trifolium pratense* lead (1.75 PDC), cadmium (3.7 MPC), zinc (1.76 MPC), copper (1.32 MPC) are found in concentrations above the permissible limit (Fig. 4).

The control point selected is the village of Taukaraturyk which is located 120 km from Almaty. Taukaraturyk was chosen because of the lack of an industrial zone, and it was also located at the foot of the mountains in the supposed clean zone. However, due to the anthropogenic load, which is mainly caused by the impact of vehicles and the presence of highways, plant samples taken from this area exceeded the permissible content of certain heavy metals, such as lead, cadmium and zinc. It should also be noted that Artemisia annua and Trifolium pratense plants have a cumulative effect on heavy metals (lead, cadmium, zinc).

The studied plants have different ability to accumulate heavy metals in their tissues. To predict the situation in order to improve it, it is necessary to regularly monitor the content of heavy metals in vegetation and soil. This will make it possible to assess the anthropogenic load using bioindication methods, as well as to reduce the risk of deterioration in public health.

To preserve plant biodiversity of the study area should be:

1) rational use of pastures. Set the normal load on the pasture. In the pasture distribution of land to regulate cattle and grazing.
2) to analyze ecosystems and develop measures for the restoration of land disturbed by the anthropogenic (man-made) impact.

Conclusion

Currently, anthropogenic load in the Almaty Region, Talgar District, has an impact on vegetation, soil and water resources. Many metals form quite strong complexes with organic matter; these complexes are one of the most important forms of migration of elements in natural waters. Most organic complexes are stable. In higher plants, the roots are characterized by a barrier-free type of accumulation of a number of chemical elements (heavy metals) in the spring in the germination phase and in the autumn-winter in rags and in the form of mineral forms (biolites), which are absent in green plants. In these circumstances, it is necessary to develop the monitoring and forecasting of the situation in order to improve it.

1) The highest accumulating species of heavy metals in all three monitoring sites are *Rumex confertus*, *Artemisia annua*, and *Trifolium pratence*.
2) Based on the results of plant analyses, it was revealed that in the entire investigated territory (in three monitoring points of Almaty region), the content of Pb, Cd, Zn, Cu, Ni, Co and Mn in plants is within the maximum permissible concentrations (MPC) or slightly exceeds the permissible level.
3) The Largest amount of heavy metals was found in plant samples collected in the study areas of the Almaty region in such species as *Artemisia annua*, *Trifolium pretense*, *Rumex confertus*.
5) Among the studied areas of the Almaty region, the content of HM in the samples of the studied plants exceeding the MPC can be noted the point of Kyzylkairat.

6) *Bromus inermis* less accumulates heavy metals compared to the other studied plants.
7) At the studied points, Besqaynar and Kyzyl Kairat all presented plant samples (*Artemisia annua*, *Trifolium pratense*, *Rumex confertus*, *Bromus inermis*) have a large storage capacity for such elements as Cd and Zn.
8) Initially conducted monitoring studies on the content of HM in plant samples of the study areas of the Almaty region can be the basis for a systematic monitoring analysis of these points.

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