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ГЕОЛОГИЯ ЖӘНЕ ТЕХНИКАЛЫҚ ҒЫЛЫМДАР СЕРИЯСЫ

♦

СЕРИЯ ГЕОЛОГИИ И ТЕХНИЧЕСКИХ НАУК

♦

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НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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M. Sh. Akhmetkaliyeva[1], L. R. Sassykova[1*], Y. A. Aubakirov[1], S. Sendilvelan[2], A. S. Zhumakanova[3], T. S. Abildin[1], A. K. Zhussupova[1], M. B. Amangeldi[1]

[1]Al-Farabi Kazakh National University, Almaty, Kazakhstan,
[2]Department of Mechanical Engineering, Dr. M.G.R Educational and Research Institute, University, Chennai-600 095, India,
[3]JSC "D. V. Sokolsky Institute of Fuel, Catalysis & Electrochemistry", Almaty, Kazakhstan.
*E-mail: larissa.rav@mail.ru

THE ACCUMULATION OF HEAVY METALS BY THE VEGETATION OF THE EAST KAZAKHSTAN

Abstract. In this article the questions of studying and assessment of the main regularities of accumulation of the heavy metals (HM): Cu, Zn, Mn, Co, Pb, Cd, in plants of the explored territory are considered at various conditions of maintaining and bioavailability of elements in the soil. The same species of a plant accumulates the different number of HM on different types of soils. The vibration amplitude of maintenance of the studied elements in species of the plants growing on various types of soils makes 1.1 – 6.3 times. Varying of the HM content in botanical plant families is in a small range. Zinc is characterized by a basipetal distribution along the morphological organs of plants, for the copper and manganese the acropetal distribution is characteristic. Cobalt, lead and cadmium are characterized by the greatest accumulation in roots with a decrease in leaves and stems. By the value of the coefficient of biological absorption Cu, Co refer to the elements of medium biological capture and weak accumulation in plants; Zn, Mn, Pb - to elements of strong biological accumulation; Cd - to elements of vigorous biological accumulation. The coefficient of biological absorption of all elements was the highest in plants of the family *Fabaceae Lindl.*

Keywords: heavy metals, biogenic migration, accumulation, botanical families, coefficient of biological absorption.

Introduction. Anthropogenic human impact on the biosphere is now global. Issues of local, regional and global dispersion and the penetration of many toxic substances with high concentrations, including heavy metals, have become very topical. A growing "metal press" on the biosphere is becoming a constantly operating environmental factor. Of great interest in this respect is the study area, which includes the territories of the former nuclear test site, as well as the lands of the reserve zone of the Abai Museum-Reserve (figure). Detailed studies in this area have not been carried out, therefore there is insufficient data on the background content of heavy metals in natural objects, including plants, which are used in most cases as a natural standard. In the presence of such data, the objectivity of assessing the emerging situation increases, it becomes possible to calculate the rate of pollution, which is necessary primarily for successful monitoring of the environment. At present, the study of the content in the environment of many toxic at high concentrations of substances is the largest social and economic problem. In connection with the growth of man's technogenic impact on the biosphere, there was a real danger of negative consequences on the environment. When solving practical problems of protecting the environment from anthropogenic pollution, an important place is occupied by information on the background content of toxic ingredients in natural objects, including plants, in a particular region. The most priority pollutants of the natural environment are heavy metals (HM), especially Pb, Cd, Zn, Cu. This is due to both the trends in the development of industry and physiological and biochemical features of HM, their high level of toxicity and the ability to accumulate in living organisms. In connection with the increase in the volume of

A map of Kazakhstan, highlighted in black - Eastern Kazakhstan

industrial production, a particularly important and urgent task is the development of scientific bases for monitoring the content of HM in natural objects, including plants, of great scientific and practical interest. Information on the background content of HM in natural areas of the study area is very valuable from a practical point of view: - give an estimate of ecosystem resilience and stability for possible climatic and geochemical changes due to global and regional anthropogenic influences; - make it possible to assume epidemic diseases among plants, animals and humans.

The problem of HM in the biosphere has two aspects - a biological one, associated with their deficiency as microelements and ecotoxicological. In this connection, it is necessary to control the content of HM in environmental objects of different regions, and first of all in plants that are the main source of most chemical elements for living organisms and a highly informative indicator of their level in the biosphere. In the scientific approach, another important circumstance is taken into account: the stably-unstable nature of the elemental composition of the plant. On the desire of living matter to retain in itself what was created by previous generations, the need to obtain current information about the environment is imposed in order to properly react to the changes occurring in it. The chemical composition of the plant has deeply specific features, as a result of the selective relationship of organisms to elements of content in the soil [1, 2]. In the geochemical environment, the conditions for redundancy or deficiency of the element for the plant are created. In different geochemical conditions, the chemical composition and metabolism of plants, even in the representatives of one species, can differ significantly [3].

Plants, extending their root system into fairly deep soil horizons due to biogenic accumulation, seem to pump chemical elements from the lower horizons to the upper horizons. After the mineralization of the plant remains in the upper horizons of the soil, those elements whose biological absorption coefficient exceeds unity are accumulated. The following factors influence the flow of TM into plants: plant specific features, soil type, concentration, form of HM finding, soil pH, its granulometric composition, organic matter content, cation absorption capacity in soil, availability of technogenic sources of ecosystem pollution [4-6]. The distribution of HM in the plant is in turn dependent on the physiological functions performed by the various organs of the plant, their morphological structure and the physiological functions performed by the chemical elements. Thus, the present selective absorption of chemical elements by plants should be considered more widely: not only as a choice of elements necessary for metabolism, but also as counteraction to the appearance of unnecessary ones. The vegetative organism has several levels of selective absorption: from less careful (on the border, the root to the environment) to the more rigid (in the terrestrial organs, especially on the border, the stem, the seed). Due to selective absorption, the chemical elements enter the plant in favorable for life proportions. The vegetation cover of the area under study is distinguished by a considerable variety and is typical of the steppe and partly desert-steppe zone.

The purpose of this study is to determine the regional background level of accumulation of HM by different species, morphological organs and families of wild vegetation of the study area.

Experimental

Zonal typical plants of the steppe and desert-steppe zone were studied, in total 100 plant samples, 18 species from six families, were studied. For tests there were taken samples of all of the genetic horizons of the soil profile. The samples of all of the genetic horizons of the soil profile were taken for investigations. Definition of macrocomposition of all tests of soils (pH, a humus, CO_2 of carbonates, granulometric composition) was carried out by standard methods [7-10]. The content of heavy metals in the explored soils was determined on the KFK-3 device by a photocolorimetric dithizone method by G.Ya.Rin'kis's recipe [6-8, 10-12]. The reproducibility of the method was equal to ± 4.2%. Selection of fractions of Pb and Zn was carried out by the method of parallel extraction. All analytical data were processed by mathematical analysis and mathematical statistics in soil science according to E.A. Dmitriev [7].

Results and discussion

Data on the ecological specifics of the accumulation of HM by the same species of plants on different types of soils are presented in table 1. As the results of studies have shown, the same plant species accumulates different amounts of HM on different soil types [7-11]. So, for example, the content of the investigated elements in plant species growing on different types of soils varies: copper - 1.1 - 3.5 times, zinc - 1.1 - 3.2 times, manganese - 1.1 - 2.5 times, cobalt - 1.1 - 2.0 times, lead - 1.1 -3.3 times, cadmium - 1.1 - 6.3 times.

The content of heavy metals in the plants in the region under investigation depends on their content in the soil, on the situation with mineral nutrition that develops in a particular soil. This is evidenced by the value of the coefficient of biological absorption (CBA), which allows one to indirectly judge the degree of

Table 1 – Content of heavy metals in plant species growing on various types of soils

Type of soil	Cu	Zn	Mn	Co	Pb	Cd
Artemisia terrae-albae Krasch						
Ch_1	1.4/0.1	13.6/0.8	84.2/0.1	0.9/0.2	1.3/0.1	0.24/0.53
M_1	1.1/0.1	14.5/0.6	61.1/0.1	0.6/0.1	0.6/0.05	0.46/0.56
S	3.8/0.2	4.6/0.2	153.9/0.2	1.2/0.2	2.0/0.2	0.2/0.1
Carex melanostachya Bieb. Ex. Wiild						
Ch_1	1.9/0.2	11.8/0.7	146.5/0.2	0.7/0.1	1.6/0.2	0.44/1.02
M_1	1.7/0.1	13.2/0.7	118.2/0.1	1.2/0.2	1.2/0.1	0.07/0.08
Goniolimon speciosum (L.) Boiss						
Ch_1	1.0/0.1	15.2/0.8	89.1/0.1	1.4/0.2	0.4/0.04	0.64/1.49
S	1.6/0.1	16.4/0.8	155.8/0.2	2.3/0.3	0.4/0.04	0.73/0.37
Limonium gmelini (Willd) O. Kuntze						
Ch_1	0.7/0.1	15.2/0.8	84.3/0.1	0.6/0.1	1.0/0.1	0.3/0.7
S	2.0/0.1	14.8/0.7	132.2/0.2	0.7/0.1	1.2/0.1	0.32/0.16
Salsola tamariskina Pall						
Ch_1	2.9/0.2	15.1/0.8	107.5/0.1	1.0/0.2	1.1/0.1	0.43/1.00
S	4.0/0.3	16.6/0.8	133.8/0.2	1.8/0.3	2.6/0.2	0.46/0.23
Stipa capillata(L.)						
Ch_1	1.7/0.1	9.4/0.5	9.4/0.01	1.7/0.2	2.2/0.2	0.19/0.72
S	3.0/0.2	10.6/0.5	10.6/0.01	1.8/0.2	4.0/0.3	0.37/1.5

Note. Ch_1 - light chestnut normal soils, M_1 - meadow light soils, S - solonchaks; in the numerator - the content of the element in the plant, mg/kg, in the denominator - the coefficient of biological absorption (CBA).

availability of elements in the soil for plants, as a rule, the higher the value of the CBA, the greater the content of the element in the plant.

Differences in the accumulation of HM by the same species on different soil types are due to both the biological characteristics of plants and the ecological condition-differences in the content and bio-availability of the elements in the soils [13-15].

According to the results of the research, the content of HM in the plants of the botanic families studied is distributed in the following order of decrease (table 2):

- on Cu: *Chenopodiaceae > Asteraceae > Cyperaceae > Poaceae, Limoneaceae > Fabaceae;*
- on Zinc: *Limoneaceae > Chenopodiaceae > Cyperaceae > Poaceae > Asteraceae > Fabaceae;*
- on Mn: *Cyperaceae > Fabaceae > Chenopodiaceae > Asteraceae , Limoneaceae > Poaceae;*
- on Co: *Poaceae > Fabaceae > Chenopodiaceae > Asteraceae , Limoneaceae > Cyperaceae;*
- on Pb: *Poaceae > Chenopodiaceae > Fabaceae > Asteraceae , Cyperaceae > Limoneaceae;*
- on Cd: *Asteraceae > Fabaceae > Limoneaceae > Chenopodiaceae > Cyperaceae, Poaceae.*

Varying the content of HM in the botanical families of plants is in a small range and amounts to an average: copper - 35.0%, zinc - 19.0%, manganese - 34.8%, cobalt - 46.7%, lead - 43.3% , cadmium - 51.5%.

Table 2 – The content of heavy metals in various botanical families of plants in the study area

Plant family	n	Cu	Zn	Mn	Co	Pb	Cd
Asteraceae Dumort. Asters	20	2.3±0.4 1.1-4.0 (53)	11.3±1.5 3.6-15.8 (42)	114.8±25.4 97.3-997.1 (70)	1.0±0.1 0.4-1.7 (44)	1.4±0.3 0.4-3.8 (64)	0.69±0.20 0.18 -2.07 (90)
Chenopodiaceae Vent. Chenopodiaceae	12	3.3±0.2 2.6-4.1 (18)	15.0±0.8 14.7-17.0 (13)	116.4±11.3 82.1-150.9 (24)	1.3±0.4 0.6-2.9 (69)	1.6±0.3 0.8-2.9 (51)	0.43±0.02 0.35-0.53 (15)
Cyperaceae Juss. Sedge	14	2.1±0.2 1.6-2.9 (24)	12.3±0.4 10.4-13.4 (9)	130.1±14.1 103.0-197.8 (29)	0.7±0.1 0.4-1.2 (39)	1.4±0.2 0.9-2.0 (30)	0.42±0.07 0.07-0.64 (45)
Fabaceae Lindl. Beans	18	1.6±0.1 1.1-2.0 (25)	10.7±0.7 7.8-14.1 (20)	128.4±13.9 91.2-188.7 (33)	1.5±0.2 0.8-2.6 (40)	1.5±0.1 1.0-2.2 (27)	0.56±0.15 0.12-1.63 (81)
Limoneaceae Lincz. Thrift	18	1.9±0.4 0.5-4.9 (66)	15.3±0.3 14.5-16.5 (6)	114.6±14.3 70.0-194.8 (37)	1.0±0.2 0.6-2.3 (55)	0.9±0.1 0.4-1.4 (44)	0.44±0.06 0.28-0.73 (42)
Poaceae Barnhart The bluegrass	18	1.9±0.2 1.4-3.0 (26)	11.5±0.8 7.7-15.9 (21)	11.3±0.6 10.3-13.8 (16)	1.6±0.2 0.6-2.3 (33)	2.0±0.3 1.2-4.0 (44)	0.42±0.05 0.19-0.73 (36)

Note. n is the number of samples; in the numerator - the arithmetic mean and its error, mg/kg; in the denominator - the range of variation, mg/kg, in parentheses - the coefficient of variation, %.

Due to selective absorption, chemical elements enter the plant in favorable proportions for life [8, 13, 14-17]. This is especially evident in various plant organs, where chemical elements have their specific function.

The distribution of HM content by plant organs is presented in table 3. It has been revealed that zinc is characterized by a basipetal distribution over the organs of plants, for copper and manganese it is acropetal. Cobalt, lead, and cadmium are differently distributed over the morphological organs of plants. They are characterized by the greatest accumulation in the roots with a decrease in leaves and stems. The stems contain a minimum number of them.

The revealed general patterns on morphological organs when considering them in the context of families (table 4) are confirmed only for one element - cadmium, for other investigated elements - they have not been confirmed. Thus, for example, the basipetal distribution of zinc and the acropetal distribution of copper and manganese by morphological organs are conserved in the family Asteraceae Dumort. and Chenopodiaceae Vent. and it looks different in other families.

Table 3 – The content of heavy metals in the organs of a common set of wild plants (n = 100)

Element	Root	Stalk (stem)	Leaf
Cu	2.6±0.3 0.5-6.3 (36)	1.8±0.3 0.5-6.3 (51)	1.7±0.3 0.5-4.1 (39)
Zn	11.8±0.7 3.4-15.8 (18)	13.9±2.8 3.5-26.6 (30)	15.1±1.0 2.7-21.2 (22)
Mn	135.7±23.7 8.6-677.6 (48)	83.5±15.2 6.3-274.7 (50)	78.4±6.7 10.0-189.0 (21)
Co	1.7±0.4 0.4-4.8 (62)	0.8±0.2 0.1-3.2 (69)	1.1±0.2 0.2-3.1 (43)
Pb	2.0±0.4 0.3-7.2 (51)	1.0±0.2 0.1-4.1 (58)	1.3±0.2 0.2-3.5 (39)
Cd	0.67±0.14 0,10-2.88 (58)	0.34±0.06 0.02-1.29 (56)	0.51±0.11 0.04-2.03 (54)
Note. n is the number of samples; in the numerator - the arithmetic mean and its error, mg/kg; in the denominator - the range of variation, mg/kg, in parentheses - the coefficient of variation, %.			

Consequently, the belonging of the plant to botanical groups (families) affects the content of the morphological organs of all heavy metals, except cadmium.

Table 4 – The content of heavy metals in the morphological organs of wild plants by family

Element	Root	Stalk	Leaf
1	2	3	4
Asteraceae Dumort- Asters (n=20)			
Cu	2.7±0.4 1.4-4.5 (50)	1.8±0.5 0.5-4.5 (78)	1.6±0.2 1.1-2.6 (31)
Zn	9.8±1.3 3.4-14.6 (40)	11.0±1.7 3.5-19.4 (49)	13.0±1.9 4.0-21.2 (46)
Mn	146.7±60.1 14.8-677.6 (98)	97.8±25.2 36.0-274.7 (81)	77.0±9.3 50.0-120.5 (32)
Co	1.4±0.3 0.8-3.7 (60)	0.7±0.2 0.1-1.9 (98)	0.8±0.2 0.2-1.8 (66)
Pb	1.6±0.3 0.3-3.6 (57)	1.3±0.3 0.5-4.0 (85)	1.4±0.1 0.7-1.8 (30)
Cd	0.96±0.27 0.21-2.88 (89)	0.45±0.12 0.09-1.29 (83)	0.79±0.26 0.24-2.03 (78)
Chenopodiaceae Vent - Chenopodiaceae (n=12)			
Cu	4.1±0.4 2.8-6.3 (31)	4.4±0.6 2.0-6.3 (46)	2.4±0.4 1.4-4.1 (40)

Continuation of table 4

1	2	3	4
Zn	14.6±0.7 11.2-15.6 (11)	14.8±1.2 9.8-17.5 (21)	16.2±0.6 13.6-18.0 (9)
Mn	180.8±13.7 130.6-208.9 (19)	87.1±23.9 42.1-174.1 (67)	81.3±3.3 69.6-89.4 (10)
Co	2.0±0.5 1.0-3.8 (54)	1.0±0.5 0.3-3.2 (98)	0.7±0.2 0.4-1.6 (69)
Pb	3.3±0.9 1.2-7.2 (65)	0.8±0.1 0.5-1.2 (36)	0.6±0.1 0.3-1.3 (55)
Cd	0.58±0.08 0.26-0.91 (36)	0.32±0.04 0.22-0.50 (34)	0.38±0.05 0.14-0.45 (32)
Cyperaceae Juss - Sedge (n=14)			
Cu	2.4±0.2 1.7-3.5 (26)	1.9±0.2 1.3-2.4 (24)	2.0±0.3 1.1-3.1 (34)
Zn	10.6±0.5 9.0-13.2 (13)	14.1±2.2 10.4-26.6 (41)	12.3±1.7 2.7-15.8 (36)
Mn	191.0±30.1 132.2-353.2 (42)	121.1±9.4 95.2-158.2 (21)	78.2±6.3 55.2-110.8 (21)
Co	1.3±0.2 0.5-2.7 (61)	0.3±0.01 0.2-0.4 (24)	0.6±0.01 0.4-0.8 (20)
Pb	1.5±0.2 0.9-2.7 (43)	0.4±0.1 0.2-0.6 (33)	2.1±0.3 1.1-3.5 (41)
Cd	0.62±0.11 0.10-1.01 (47)	0.25±0.06 0.02-0.43 (59)	0.38±0.07 0.09-0.67 (52)
Fabaceae Lindl - Beans (n=18)			
Cu	2.1±0.3 1.2-3.3 (38)	1.1±0.1 0.6-1.8 (34)	1.8±0.3 1.0-3.6 (46)
Zn	12.4±0.6 8.4-14.4 (15)	9.8±1.0 6.8-15.8 (30)	9.8±0.9 7.0-15.1 (28)
Mn	174.3±21.9 110.6-275.3 (38)	89.2±12.2 75.6-171.5 (41)	105.7±9.4 80.0-142.6 (27)
Co	2.2±0.3 0.8-3.3 (45)	1.1±0.3 0.2-2.8 (72)	1.2±0.1 0.7-1.6 (31)
Pb	2.0±0.3 0.6-3.3 (46)	1.3±0.3 0.6-3.1 (60)	1.5±0.1 0.9-2.0 (28)
Cd	0.82±0.23 0.12-2.43 (85)	0.35±0.08 0.09-0.91 (65)	0.52±0.14 0.04-1.54 (84)

End of table 4

1	2	3	4
Limoneaceae Lincz – Thrift (n=18)			
Cu	2.1±0.3 0.5-3.3 (46)	1.1±0.2 0.5-1.7 (44)	1.2±0.2 0.5-2.0 (48)
Zn	13.7±0.5 12.0-15.8 (11)	16.3±0.6 14.0-19.2 (12)	15.9±0.5 13.0-17.8 (9)
Mn	111.4±16.1 67.6-196.3 (43)	92.7±19.3 39.4-231.9 (62)	117.3±11.9 80.2-189.0 (30)
Co	1.6±0.4 0.6-4.8 (82)	0.6±0.1 0.2-0.8 (39)	1.1±0.2 0.6-1.5 (36)
Pb	1.3±0.2 0.5-2.0 (47)	0.6±0.1 0.1-1.0 (60)	0.9±0.2 0.2-1.5 (55)
Cd	0.55±0.08 0.30-0.92 (43)	0.32±0.03 0.30-0.60 (48)	0.45±0.06 0.30-0.75 (40)
Poaceae Barnhart – The bluegrass (n=18)			
Cu	2.2±0.2 1.1-2.80 (24)	1.6±0.4 0.8-4.9 (79)	1.8±0.3 1.2-2.8 (34)
Zn	9.9±0.5 8.6-13.6 (15)	12.9±1.2 10.6-18.2 (28)	11.1±0.3 10.0-12.1 (7)
Mn	9.9±0.5 8.6-13.6 (15)	12.9±1.2 6.3-18.2 (28)	11.1±0.3 10.0-12.1 (7)
Co	1.5±0.4 0.4-4.1 (73)	1.3±0.3 0.5-2.7 (73)	2.0±0.3 0.9-3.1 (38)
Pb	2.3±0.4 0.8-4.6 (50)	1.5±0.4 0.8-4.1 (74)	1.6±0.2 1.1-2.2 (28)
Cd	0.48±0.07 0.13-0.68 (45)	0.36±0.06 0.14-0.68 (47)	0.44±0.06 0.20-0.72 (38)

Note. n is the number of samples; in the numerator - the arithmetic mean and its error, mg/kg; in the denominator - the range of variation, mg/kg, in parentheses - the coefficient of variation, %.

The intensity of absorption (coefficient of biological absorption, CBA) [16, 18-22] of heavy metals by various organs and plant families as a whole has been studied.

On average for copper, zinc is characterized by intense absorption by stems, less leaves, roots: $CBA_{stalk} > CBA_{leaf} > CBA_{root}$; for lead, manganese - $CBA_{root} > CBA_{stalk} > CBA_{leaf}$; for cobalt, cadmium - $CBA_{root} > CBA_{list} > CBA_{stalk}$.

In the calculation formula, the CBA used the values of clarke elements for the soil.

According to the level of the mean value of the CBA, the plant families are arranged in the following descending order:

- on Cu: *Fabaceae* (1.9) > *Chenopodiaceae* (1.7) > *Poaceae* (1.4) > *Asteraceae, Cyperaceae* (1.1) > *Limoneaceae* (0.9);

- on Zn: *Fabaceae* (5.0) > *Limoneaceae* (3.8) > *Poaceae* (3.5) > *Chenopodiaceae* (2.9) > *Cyperaceae* (2.7) > *Asteraceae* (2.3);

- on Mn: *Fabaceae* (3.6) > *Cyperaceae* (1.6) > *Limoneaceae* (1.5) > *Chenopodiaceae* (1.4) > *Asteraceae* (1.1) > *Poaceae* (0.2);

- on Co: *Fabaceae* (3.5) > *Poaceae* (2.1) > *Cyperaceae* (1.8) > *Limoneaceae* (1.4) > *Chenopodiaceae* (1.2) > *Asteraceae* (1.0);

- on Pb: *Fabaceae* (3.8) > *Poaceae* (2.8) > *Chenopodiaceae* (1.5) > *Asteraceae, Cyperaceae* (1.3) > *Limoneaceae* (1.5);

- on Cd: *Fabaceae* (22.35) > *Asteraceae*(13.53) > *Poaceae*(13.93) > *Limoneaceae*(11.09) > *Chenopodiaceae*(8.46) > *Cyperaceae* (7.97).

As can be seen from these series, the CBA of all elements appeared to be higher in the plants of the family *Fabaceae Lindl.*

In general, for the area under study, it is characteristic that copper, manganese, cobalt, and lead are classified as a group of elements of average absorption by the level of biological absorption of plants; zinc, cadmium - to the group of elements of intensive absorption. For the latter, biogenic migration, apparently, can act as the main factor in the migration of these elements in the landscape.

Conclusion. As a result of the study, it was found that differences in the accumulation of heavy metals by the same species on different types of soils are due to both the biological characteristics of plants and the ecological condition - differences in the content and bioavailability of elements in a particular soil. The same plant species accumulates different amounts of heavy metals on different soil types. The content of the investigated elements in plant species growing on different soil types varies: copper - 1.1 - 3.5 times, zinc - 1.1 - 3.2 times, manganese - 1.1 - 2.5 times, cobalt - 1.1 - 2.0 times, lead - 1.1 -3.3 times, cadmium - 1.1 - 6.3 times. Varying of the content of heavy metals in botanical plant families is in a small range and amounts to an average: copper 35.0%, zinc 19.0%, manganese 34.8%, cobalt 46.7%, lead 43.3 %, cadmium - 51.5%. Zinc is characterized by a basipetal distribution according to the morphological organs of plants, and acropetal distribution is typical for copper and manganese. Cobalt, lead and cadmium are characterized by the greatest accumulation in roots with a decrease in leaves and stems (stalk). The stems contain a minimum number of them. For copper, zinc is characterized by intense absorption by stems, less leaves, roots, the coefficient of biological absorption (CBA): $CBA_{Stalk\ (stem)} > CBA_{leaf} > CBA_{root}$; for Pb, Mn – $CBA_{root} > CBA_{stalk\ (stem)} > CBA_{leaf}$; for Co, Cd – $CBA_{root} > CBA_{leaf} > CBA_{stalk\ (stem)}$. By the value of CBA Cu, Co refers to the elements of medium biological capture and weak accumulation in plants; Zn, Mn, Pb - to elements of strong biological accumulation; Cd - to elements of vigorous biological accumulation. CBA of all elements was higher in plants of the family *Fabaceae Lindl.*

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М. Ш. Ахметқалиева[1], Л. Р. Сасыкова[1], Е. А.Әубәкіров[1], С. Сендилвелан[2], А. С. Жұмақанова[3], Т. С. Абильдин[1], А. К. Жусупова[1], М. Б. Амангелді[1]

[1]Әл-Фараби атындағы Қазақ ұлттық университеті, Алматы, Қазақстан,
[2]Машина жасау факультеті, М.Г.Р. оқу және ғылыми-зерттеу институты,
University, Chennai-600 095, Үндістан,
[3]Д. В. Сокольский атындағы Жанармай, катализ және электрохимия институты АҚ, Алматы, Қазақстан.

ШЫҒЫС ҚАЗАҚСТАН ӨСІМДІКТЕРІНДЕ АУЫР МЕТАЛДАРДЫҢ ЖИНАҚТАЛУЫ

Аннотация. Мақалада ауыр металдардың (АМ): Cu, Zn, Mn, Co, Pb, Cd зерттеу аймағындағы өсімдіктердегі топырақтағы элементтердің құрамдары мен биологиялық қол жетімділігі әртүрлі жағдайларда жинақталуының негізгі заңдылықтарын зерттеу және бағалау қарастырылған. Өсімдіктердің бір ғана түрі әртүрлі топырақта АМ-дың әртүрлі мөлшерін жинайды. Әртүрлі топырақта өсетін өсімдік түрлерінде зерттелген элементтердің құрамындағы ауытқулардың амплитудасы 1,1-6,3 есе. Ботаникалық өсімдіктер тұқымдастарындағы АМ-дың құрамдарының өзгеруі шағын ауқымда. Цинк өсімдіктердің морфологиялық мүшелері бойынша базипеталды таралумен сипатталса, ал мыс пен марганец – акропеталды. Кобальт, қорғасын және кадмий үшін жапырақтары мен сабақтарының төмендеуімен тамырлардағы ең көп жинақталу көрсетілді. Биологиялық сіңіру коэффициентінің мәні бойынша Cu, Co орта биологиялық басып шығару элементтеріне және өсімдіктерде нашар жинақтауға жатады; Zn, Mn, Pb – күшті биологиялық жинақтау элементтеріне; Cd – дәрменді биологиялық жинақтау элементтеріне жатады. Барлық элементтердің биологиялық сіңіру коэффициенті бойынша өсімдіктердің Fabaceae Lindl тұқымдасында ең жоғары болды.

Түйін сөздер: ауыр металдар, биогенді миграция, аккумуляция, ботаникалық тұқымдастар, биологиялық сіңіру коэффициенті.

М. Ш. Ахметкалиева[1], Л. Р. Сасыкова[1], Е. А. Аубакиров[1], С. Сендилвелан[2], А. С. Жумаканова[3], Т. С. Абильдин[1], А. К. Жусупова[1], М. Б. Амангелды[1]

[1]Казахский национальный университет им. аль-Фараби, Алматы, Казахстане,
[2]Department of Mechanical Engineering, Dr. M.G.R Educational and Research Institute,
University, Chennai-600 095, India,
[2]АО «Институт топлива, катализа и электрохимии им. Д. В. Сокольского», Алматы, Казахстан

НАКОПЛЕНИЕ ТЯЖЕЛЫХ МЕТАЛЛОВ РАСТИТЕЛЬНОСТЬЮ ВОСТОЧНОГО КАЗАХСТАНА

Аннотация. В настоящей статье рассматриваются вопросы изучения и оценки основных закономерностей накопления тяжелых металлов (ТМ): Cu, Zn, Mn, Co, Pb, Cd в растениях исследуемой территории при различных условиях содержания и биодоступности элементов в почве. Один и тот же вид растения накапливает разные количества ТМ на разных типах почв. Амплитуда колебаний содержания исследуемых элементов в видах растений, произрастающих на различных типах почв, составляет 1.1 – 6.3 раза. Изменение содержания ТМ в семействах ботанических растений находится в небольшом диапазоне.

Для цинка характерно базипетальное распределение по морфологическим органам растений, для меди и марганца – акропетальное. Для кобальта, свинца и кадмия характерно наибольшее накопление в корнях с уменьшением в листьях и стеблях. По значению коэффициента биологического поглощения Cu, Co относится к элементам среднего биологического захвата и слабого накопления в растениях; Zn, Mn, Pb – к элементам сильного биологического накопления; Cd – к элементам энергичного биологического накопления. Коэффициент биологической абсорбции всех элементов оказался наиболее высоким в растениях семейства Fabaceae Lindl.

Ключевые слова: тяжелые металлы, биогенная миграция, аккумуляция, ботанические семейства, коэффициент биологического поглощения.

Information about authors:

Maksat Shaimerdenovna Ahmetkaliyeva – Ph.D., Prof. of the Department of Physical Chemistry, Catalysis and Petrochemistry, Faculty of Chemistry and Chemical Technology, al-Farabi KazNU. Maksat. Ahmetkaliyeva @kaznu.kz

Larissa Ravil'evna Sassykova – Ph.D., Ass.Prof. of the Department of Physical Chemistry, Catalysis and Petrochemistry, Faculty of Chemistry and Chemical Technology, al-Farabi KazNU. e-mail: larissa.rav@mail.ru

Yermek Aiktazynovich Aubakirov – Prof., Head of the Department of Physical Chemistry, Catalysis and Petrochemistry, Faculty of Chemistry and Chemical Technology, al-Farabi KazNU. e-mail: miral.64@mail.ru

Subramaniam Sendilvelan – Dean, Prof., Department of Mechanical Engineering, Dr.Sc. M.G.R Educational and Research Institute, University, Chennai, India (Hirsch index 9). e-mail: sendilvelan.mech@drmgrdu.ac.in

Ardak Sydykovna Zhumakanova – Ph.D., Scientific secretary of JSC "DV Sokolsky Institute of Fuel, Catalysis and Electrochemistry" e-mail: zhumakanova62@mail.ru

Tleutai Sarsenbaevich Abildin – Prof. of the Department of Physical Chemistry, Catalysis and Petrochemistry, Faculty of Chemistry and Chemical Technology, al-Farabi KazNU. e-mail: abildin54@mail.ru

Aisulu Kairgeldinovna Zhussupova – Ph.D., sen.lect. of the Department of Physical Chemistry, Catalysis and Petrochemistry, Faculty of Chemistry and Chemical Technology, al-Farabi KazNU. e-mail: Aisulu.Zhusupova@kaznu.kz

Magzhan Baukenuly Amangeldy – bachelor of the Department of Physical Chemistry, Catalysis and Petrochemistry, Faculty of Chemistry and Chemical Technology (specialty "Chemical technology of organic substances"). e-mail: amangeldi.magzhan@gmail.com

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