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Studies of Regularities of Accumulation and Dispersion of Chemical Elements in Soils of the South Aral Regions

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1. Introduction

When assessing the ecological state of agricultural landscapes in the Aral Sea region, the study of techno genic factors, which are superimposed on the entire complex of natural processes, is of decisive importance. The most dangerous type of techno genic impact on the natural environment is environmental pollution by chemical elements that are involved in biological, hydrogeochemical, biogeochemical and other processes. The relationship between these processes is not studied well. Moreover, the biogenic and sedimentation processes of purification and self-purification of ecosystems in interconnection with each other have not yet been studied sufficiently. Therefore, we carried out an ecological-geochemical study of waters, soils, bottom sediments of this region by the method of multielement instrumental neutron activation analysis.

The content of chemical elements in strong and moderately saline soils of agrolandscapes of Karakalpakstan

Soil is a special natural formation, it consists of genetically related horizons, is a storage and converter of substances in it, a bumper on the path of pollution, possesses special properties inherent in animate and inanimate nature. In the biogeochemical chain, the migration of chemical elements of the soil it occupies a central place. Under the conditions of the Aral Sea region, where the processes of soil salinization are taking place everywhere, the knowledge of the regularities of the formation of the elemental composition of soils, the accumulation of elements in them, and their dispersion along the biogeochemical chain is of scientific and practical importance. In this regard, we studied the elemental composition of soils in the main agricultural landscapes of the Aral Sea zone.

The first attempts on the study of the ecological-agro-geochemical conditions of soils was carried out in 1990-2002 by B. Ibragimov, A. Zhumamuratov [28, 79].

These works showed the enrichment of soils with Na, Cl, Zn, Cu, As, Sb, Se, Br, Hf, Ta, U, REE and the simultaneous depletion of soils with K, Sc, Mn, Fe, Co, Ba, Sr, and there designed a map of the distribution of Na in the soils of the northern part (above the city of Nukus) of Karakalpakstan. Further observations of the ecological and agro-geochemical state of soils at the same places were conducted by us in recent years, the purpose of which is not only to learn the degree of soil pollution, but also to establish other soil parameters. In particular, the relationship between the elemental composition of soils and irrigation water was studied, the degree of solubility of individual chemical elements in water was estimated by us.

The instrumental neutron activation analysis (INAA) results for moderately and highly saline soils of some agricultural landscapes are shown in Table 1.

Soil samples were taken from the arable layer of the Ellikkala region (Bostan farm) - moderately saline soils, and samples of highly saline soils in the Muynak region (the vicinity of Muynak) and the environs of Nukus city. Due to the fact that the Ellikkala region is located far from the Aral Sea (380 km), and also, according to the data [1], the soils of this region are less susceptible to salinization, this region was taken as a model and the data on the elemental composition of soils obtained from two other regions were compared with those of Ellikkala. Below we are going to write the results of our comparison of the average content of elements in the soils of the Muinak (Cm) and Nukus (Cn) regions with the data for the Ellikkala (Ce) region.

Table 1: The content of chemical elements in the arable soil of some regions of Karakalpakstan (mg / kg)

	Ellikkala region	Muynak region		Nukus region		$\overline{C}$	$\overline{C}$[1]	$\overline{C}/\overline{C}$[1]
	$\overline{C}_Э$	$\overline{C}_M$	$\overline{C}_M/\overline{C}_Э$	$\overline{C}_H$	$\overline{C}_H/\overline{C}_Э$			
Na%	1,3	4,5	3,5	2,8	2,2	2,87	**1,7**	1,69
K%	1,1	1,58	1,43	2,2	2,0	1,63	**1,8**	0,91
Sc	11,5	7,3	0,60	9,8	0,8	9,54	**7,8**	1,22
Cr	46,7	25,8	0,50	55,0	1,1	24,3	**75,3**	0,32
Mn	624,0	450,0	0,72	496,8	0,80	523,6	**434**	1,21
Fe%	1,85	1,52	0,84	1,35	0,73	1,57	**1,4**	1,12
Co	11,7	8,2	0,70	9,84	0,86	9,91	**8,9**	1,11

Rb	35,9	50,9	1,42	41,2	1,15	56	**52,7**	1,06
Y	29,0	34,0	1,17	33,0	1,3	32	**-**	-
Zr	11,0	13,2	1,2	12,4	1,1	12,2	**-**	-
Sb	3,6	2,61	0,72	2,25	0,61	2,82	**1,6**	1,76
Cs	6,50	3,86	0,59	3,50	0,54	4,29	**1,6**	2,68
Ba	967,0	635,0	0,66	400,0	0,41	667,3	**340**	1,96
La	33,6	19,2	0,57	26,9	0,80	26,53	**19**	1,59
Ce	30,6	26,7	0,87	27,0	0,73	28,1	**18,1**	1,56
Sm	2,5	2,1	0,84	3,7	1,48	2,77	**2,9**	0,96
Eu	0,90	1,07	1,18	1,72	1,91	1,23	**1,0**	1,23
Tb	3,7	3,5	0,95	5,2	1,41	4,13	**3,3**	1,25
Yb	1,2	1,50	1,25	1,38	1,15	1,36	**1,8**	0,78
Hf	2,3	2,12	0,91	2,30	1,0	2,21	**3,5**	0,63
Th	5,2	4,88	0,94	6,3	1,21	5,7	**5,3**	1,1
U	2,82	2,60	0,93	2,1	0,75	2,51	**2,1**	1,2

Sodium and potassium: The Na content decreases from north to south according to the Muynak-Nukus-Ellikkala scheme. The potassium content is maximum (2.2%) in the soils of the vicinity of Nukus, minimum is in the soils of the Ellikkala region (1.1%). A high potassium content indicates that these soils are either not used for a long time in agricultural use, or are contaminated with uncontrolled application of potassium fertilizers.

Iron, Manganese, Cobalt: For this group of elements, the enrichment of the soils of the Ellikkala region is found. Compared to other regions, we note that the contents of Fe, Mn, Co in soils are relatively low compared to other republics [2], and a deficiency of these elements can cause anemia and other diseases, i.e. the content is insufficient for the normal course of metabolic processes in plants, animals and humans [3].

Scandium and REE (La, Ce, Sm, Eu, Tb, Yb: The biological role of this group of elements has not been studied thoroughly, although these elements are always found in the composition of soils, plants, in organs and tissues of animals and humans. The studies [47] show the participation of these elements in the pathogenesis of cotton wilt, hepatitis and diabetes mellitus in humans, in particular, a relationship was found between the content of scandium and the amount of sugar in the blood of sick and healthy people. From table 3.1.it can be seen that the soils of the Ellikkala region and the environs of Nukus and Muynak regions are enriched with these elements and distributed more evenly within the limits of the determining elements. We are inclined to explain this situation by the fact that this group of elements is included in the composition of phosphorus fertilizers, and their implementation led to the contamination of the soils of this region.

Rubidium, Cesium, Barium: Elements of this group are analogs of Na, K and Ca. Their content (with the exception of Ba) is higher in the soils of the Muynak region, but in the Nukus region, the content is slightly lower. The enrichment of soils in the Ellikkala region (967.0 mg / kg) with barium can be explained by the violation of the Ca / Ba or Mg / Ba ratio, which leads to the depletion of Ca or Mg soils and is associated with a change in the pH of the medium (pH-8.9), or the composition humus in soils.

Thorium and uranium: The maximum content of thorium was found in the arable layer of the soils of the Nukus region (6.6 mg / kg), Ellikkala (5.2 mg / kg), and the minimum in the soils of the Muynak region (4.88 mg / kg). In the case of uranium, we see quite the opposite picture: Ellikkala (2.82 mg / kg), Muynak (2.60 mg / kg), Nukus (2.10 mg / kg). These elements, along with the natural components, have anthropogenic components, so here we find violations of their relationship, which are associated with the ecological situation in the region. The average data obtained by us for Th and U is 1.05 and 1.2 times higher than the average data for Karakalpakstan [1]. An insignificant increase in the content of these elements in soils is found.

Antimony: The maximum content of antimony was found in the soils of the Ellikkala region (3.60 mg / kg), and the minimum in the soils of the vicinity of Nukus (2.25 mg / kg). This element is included into the group of pesticides. The obtained results on antimony have no anthropogenic impact on the environment, although this statement requires additional research on the participation of antimony in the biogeochemical chain.

A comparative analysis of our results ($\overline{C}$) with the data given in other studies [1] shows that over 8-10 years (our samples were taken at the same places) the arable soil layer was enriched with Na, Sc, Mn, Fe, Co, Rb, Sb , Cs, Ba, La, Ce, Eu, Tb, Th, U and other chemical elements. The cotton has been cultivated in the soils of the designated sampling points (with the exception of three out of seven sampling points in Muynak) for a long time. Therefore, the decrease of K, Cr, Sm, Yb, Hf in the content of the soil can be associated with the regular cotton planting.

The process of enrichment of soil with Na, Sb, Cs, Ba, La, Ce we associate with irrigation of saline waters, the including of aerosol particles, the using of mineral fertilizers (in the case of REE, Sc, Th, U) and with the raising the level of groundwater to the surface, which contain high concentrations of many chemical elements (Table 1).

In particular, the content of chemical elements in the arable layer has increased 1.05-2.6 times over the 10 years. To establish the reliability of such a statement, it is required to conduct systematic studies of time and space on a sufficiently large statistical material that is planned for the future.

In conclusion, it should be noted that the content of many elements in soils is low (with the exception of Na, K), and due to the alkaline reaction of the environment and the oxidizing situation, their mobility in the Aral Sea region is low. Therefore, plants, animals and humans may experience their deficit, which can be seen in the example of a decrease in the productivity of soils in the regions. Soil salinization led to a quantitative and qualitative change in the regularity of the migration of chemical elements in the biosphere of the region due to a decrease in the accumulation of biophilic elements, a violation of the ratio between elements and an increase in the proportion of toxicants in the soil. Therefore, in this regard, it is important to study the regularities of the distribution of a wide range of chemical elements along the soil profile.

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