

Section 3. Technical sciences

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ION-SALT COMPOSITION OF WESTERN DEEP-WATER PART OF GREAT ARAL SEA AND ITS VARIABILITY

Abstract. The process of draining the bottom of the Aral Sea is relative to the content of individual ions, which depends on the regions of the staged salt formations. Based on the results of the studies, measures were developed the relative content of which decreased from the dried bottom of the Aral Sea. Our drilling of the bottom of the Aral Sea showed that the thickness of soil sediments from the south to the north ranges from 2 to 6 m with a humidity of 40–80%. Salt content of groundwater was 0,4–0,9% lower compared to seawater.

Based on studies conducted to establish the distribution patterns of clay materials and soluble salts in the soil, the western shore of the Great Aral Sea was divided into three layers. In the first layer, there is no pattern of change in the observed indicators. The second and third layers separately and the relationships have certain patterns. It has been found that in the second layer, with increasing depth, the content of clay components of the soil decreases, and at the beginning of the third layer it increases again, but less than at the beginning of the second layer. These phenomena affect the distribution of soluble salts.

Keywords: Aral Sea, ions, reduction, sulfate-chloride, water retention, depths, soils, regularity, water-soluble salts.

Introduction. The Aral Sea is located within Uzbekistan and Kazakhstan in the northern part of the desert regions of Central Asia between 43°28' and 46°52' N and 58°4' and 61°56' E from Greenwich. The name “Aral Sea” – from the word “Aral” is associated with the fact that the huge basin lies on an island among the waterless deserts of the Turan lowland. The water area of the Aral Sea in the west is limited by steep chinks, an extensive plateau stretching to the Caspian Sea, the Ustyurt plateau, rising 100–200 m above the level of the Aral Sea. In the south is the flat space of the modern and ancient Amu Darya Delta, south turning into velvet sand massifs of the Zanguz Karakums. In the east it borders on Kyzylkum – a desert plain with a common slope towards the sea. In the north and north-west, the coastline of the water area is limited to the barley sands of the Mugojar foothills [1].

In connection with the beginning of an intensive decrease in the level of the Aral Sea and the emergence of the first fears about its possible complete disappearance in the future in the early 60 s, research began on the problem of the Aral Sea.

Most researchers (B. V. Andrianov, A. S. Kes, P. V. Fedorov, etc.), based on geological and historical surveys, came to the almost consensus that in prehistoric times, changes in the level and salinity

of the Aral Sea occurred due to changes in the natural climate. During the humid climatic phase, the sea level reached a maximum value of 72–73 m abs, and during the arid climate, the Aral level fell, and the degree of salinity of the Aral Sea grew [2–6].

Research objects and methods. The object of research in this work is salt-forming ions in water, and the soil of the lowered bottom of the Aral Sea of the Muinak region.

Research material and methodology. Water extraction of soils was prepared according to the generally accepted method-soil: water in a ratio of 1:5 [7]. The content of chlorine ions was determined by argentometric methods by sea; calcium and magnesium trilonometric; sulfate by titration; aqueous drawing with a sulfuric acid solution in the presence of a methyl orange indicator; sodium and potassium ions by the difference in the sum of anions and cations. The results of the analysis of aqueous extracts were expressed in milligram equivalents per 100 g of dry air soil, the sum of water-soluble salts in percent.

The results of the aqueous extract analysis were monitored for a dense (dry) residue.

The degree of soil salinity was assessed on a scale of [7–9].

Table 1. – Relative contents (% by weight) of the main salt-forming ions in the water of the Great Aral Sea in 2020 and 2022

No	Soil type	total HCO ₃ ⁻ in%	Cl ⁻ %	SO ₄ ⁻² %	Ca ⁺ %	Mg ⁺ %	Anions-cations mg/eq	Na+K by difference in%	Note
1	25.06.20	4.88	14.2	168.0	4.008	23.69	3980/2150	45.75	170
2	05.12.20	7.32	14.2	86.4	7.014	13.36	2320/1450	21.75	170
3	05.03.21	4.88	14.2	122.4	4.008	20.04	3030/1850	29.5	160
4	07.07.21	3.66	10.6	117.6	5.01	18.22	2810/1750	26.5	170
5	08.09.21	4.88	14.2	91.2	5.01	15.18	2380/1500	22.0	170
6	25.02.22	3.66	10.6	72.0	4.008	17.61	1860/1650	5.25	170
7	07.03.22	4.88	10.6	72.0	3.006	20.04	1880/1800	2.0	180
8	10.05.22	3.66	21.3	72.0	3.006	19.44	2160/1750	10.25	180

Research results

It can be seen that the relative contents of individual ions before the start of sea drying and in

2020–2022 differ quite significantly. The most significant changes occurred with the Ca₂⁺ ion, the relative content of which decreased. This fact is not surpris

ing, since the curing of calcium carbonate and gypsum should lead to the effective removal of calcium from the aqueous mass. The content of sulfate ion, which is also consumed during gypsum deposition, has also decreased. The content of the Cl^- ion, on the contrary, has grown. Due to the last two facts, the sulfate-chloride ratio of $\text{SO}_4^{2-}/\text{Cl}^-$, considered an important characteristic of the chemical type of the reservoir, decreased by 42%. Thus, during the drying of the Aral Sea, its belonging to the class of sulfate-type reservoirs became less pronounced, and the waters of this sea to some extent approached the chloride type characteristic, in particular, of ocean waters. Also, the relative content of the HCO_3^- ion consumed as a result of the carbonates was significantly reduced (by about 0.5 times).

Consistent changes in the ion-salt composition of the waters of the Great Aral Sea 2020–2022 show that in the samples of 2022, the relative calcium content was 3.006% (compared with 7.014 in 2020).

Thus, the calcium content was reduced before our eyes by the curing of minerals, and this process was quite visible, even in a relatively short observation period. This ratio should be less sensitive to the precipitation of salts in interannual time scales, since only relatively small fractions of the available mass of chloro-ion and sulfate-ion are involved in these processes, in contrast to Ca_2^+ and HCO_3^- , a significant part of which has already fallen. Also, during the analysis, the chemical compositions of soil samples obtained from the western shore of the deep-water western part of the Great Aral Sea were studied in (Table 2).

No changes in observed parameters were observed in the first layer. The indicators of the second and third layers changed according to certain patterns.

Table 2. – Chemical composition of soil samples obtained from the western shore of the deep-water western part of the Great Aral Sea

№	Sam-pling date	Coordinates		Sam-pling depth, cm	Dry Stock Current	total HCO_3 in%	Cl^-	SO_4^- %	Ca%	Mg%	Anions-cations mg/eq	Na+K by difference in%	Sum of components in%	Sa-linity type	pH
		northern latitude	east longi-tude												
1	31.05.22	44°04'811	58°26'146	0–5	5.069	0.214	0.44	2.88	0.25	0.47	76.0/51.2	0.57	4.829	X–C	8.0
2	31.05.22	44°04'811	58°26'146	5–10	2.152	0.073	0.17	1.27	0.29	0.18	32.7/30.0	0.06	2.063	–C–	8.0
3	31.05.22	44°04'811	58°26'146	10–23	4.855	0.153	0.44	2.82	0.45	0.42	73.7/57.5	0.37	4.667	X–C	8.0
4	31.05.22	44°04'811	58°26'146	23–32	3.161	0.153	0.53	1.50	0.52	0.25	48.7/47.5	0.02	2.999	X–C	8.0
5	31.05.22	44°04'811	58°26'146	32–51	3.129	0.122	0.26	1.74	0.47	0.18	45.7/38.7	0.16	2.947	X–C	8.0
6	31.05.22	44°04'811	58°26'146	0–5	2.318	0.061	0.14	1.39	0.42	0.13	34.0/32.0	0.04	2.196	–C–	8.0
7	31.05.22	44°04'811	58°26'146	5–10	2.429	0.073	0.14	1.41	0.51	0.01	34.7/26.5	0.19	2.313	–C–	8.0
8	31.05.22	44°04'811	58°26'146	10–17	2.174	0.073	0.10	1.27	0.27	0.06	30.7/19.0	0.27	2.058	–C–	8.0
9	31.05.22	44°04'811	58°26'146	17–32	1.728	0.061	0.17	0.93	0.34	0.08	25.5/24.0	0.03	1.635	X–C	8.0
10	31.05.22	44°04'811	58°26'146	32–47	1.705	0.085	0.10	1.00	0.20	0.16	25.4/23.5	0.04	1.607	–C–	8.0
11	31.05.22	44°04'811	58°26'146	47–67	1.448	0.061	0.14	0.81	0.16	0.14	22.3/20.0	0.04	1.371	X–C	8.0

For example, with an increase in depth from 5–23 cm, the dry residue and the sum of salts and components increase, and in the third layer some indicators decrease and make Cl⁻ 0.53–0.26%, Ca 0.52–0.47%, Mg 0.25–0.18%.

The results of analysis of samples from the fourth well show that with an increase in the depth of the section from 0 to 67 cm, the sum of salts and components in the samples increases, which means a decrease in the content of clay substances in the insoluble part of the samples. Here, as well as in other well sections, soluble salts contain mainly chlorine and sulfate ions. Thus, the compositions of water-soluble salts in soil samples from the north to the southeast of the greater Aral Sea vary from sulfate to chloride-sulfate and chloride. The soil surface is covered with wrinkled clay with large cracks 15–30 cm wide, 5–10 m long and 1.0–2.0 m deep.

Conclusions

Thus, mirabilite salt deposits occur on the eastern shore of the western deep-water part of the Great

Aral Sea, which form in winter, and dissolve in precipitation in spring-summer.

Based on studies conducted to establish the distribution patterns of clay materials and soluble salts in the soil, the western shore of the Great Aral Sea was divided into three layers. In the first layer, there is no pattern of change in the observed indicators. The second and third layers separately and the relationships have certain patterns. It has been found that in the second layer, with increasing depth, the content of clay soil components increases, and at the beginning of the third layer, some components again decrease, but less than at the beginning of the first layer. These phenomena affect the distribution of soluble salts. By chemical and physicochemical methods of studying water-soluble salts and water-insoluble soil residue, it was established that the samples contain the following water-soluble minerals: mirabilite, tenardite, halite, blödite, cognavite, leveite, vantgoffite, pentahydrate, starkeite, sanderite and kieserite.

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